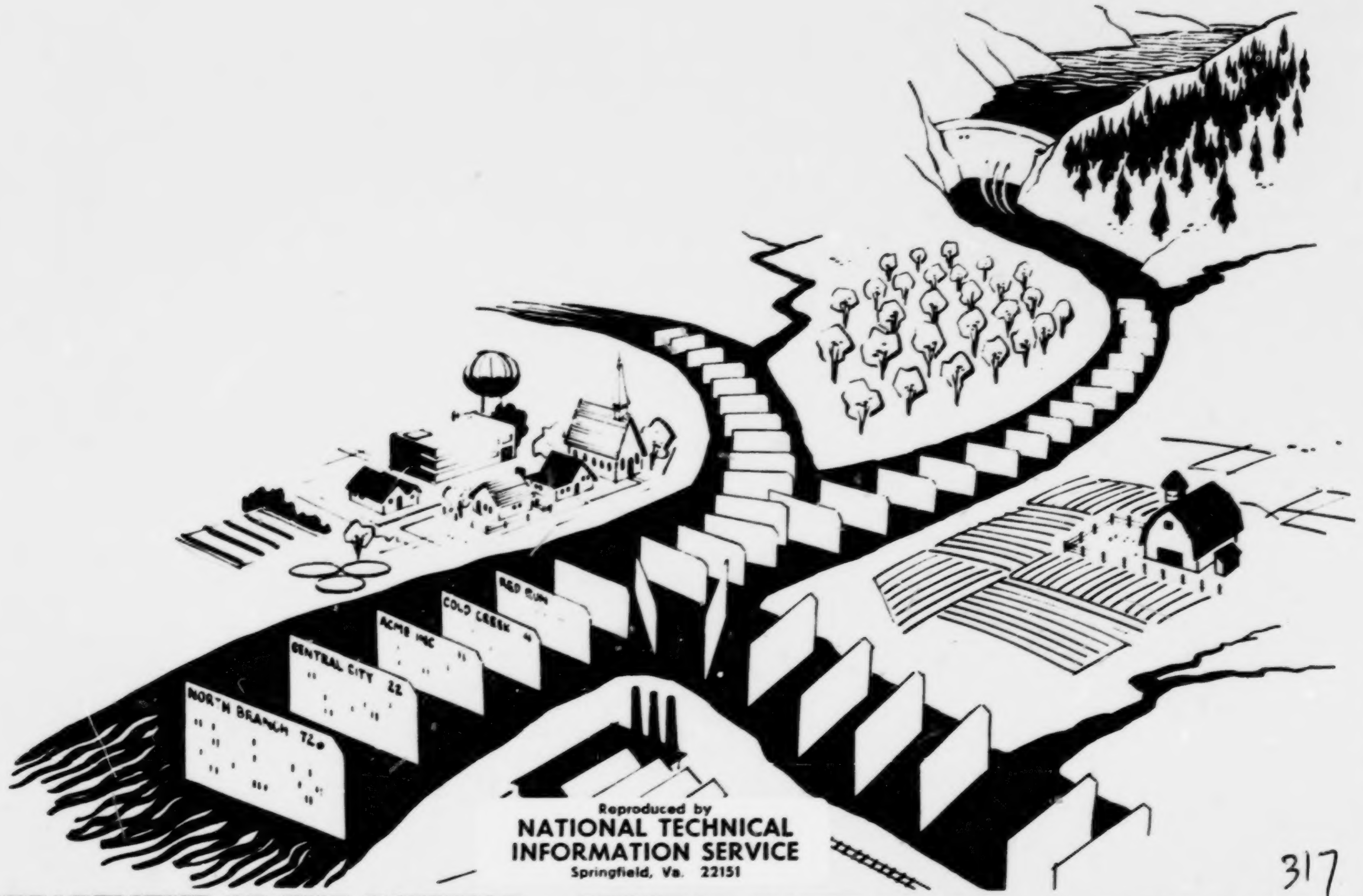
CLEAN WATER WATER POLLUTION CONTROL RESEARCH SERIES • 16090 DBJ 08/70

PB195675

W71-01264

Design of Water Quality Surveillance Systems


NORTH BRANCH 72
CENTRAL CITY 22
ACME INC
COLD CREEK
RED RUN

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

317

S. DEPARTMENT OF THE INTERIOR • FEDERAL WATER QUALITY ADMINISTRATION

WATER POLLUTION CONTROL RESEARCH SERIES

The Water Pollution Control Research Reports describe the results and progress in the control and abatement of pollution in our Nation's waters. They provide a central source of information on the research development, and demonstration activities in the Federal Water Quality Administration, in the U. S. Department of the Interior, through inhouse research and grants and contracts with Federal, State, and local agencies, research institutions, and industrial organizations.

A tripilicate abstract card sheet is included in the report to facilitate information retreieval. Space is provided on the card for the user's accession number and for additional uniterms.

Inquires pertaining to Water Pollution Control Research Reports should be directed to the Head, Project Reports System, Planning and Resources Office, Office of Research and Development, Department of the Interior, Federal Water Quality Administration, Room 1108, Washington, D. C. 20242

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $3.00

Design of Water Quality Surveillance Systems

Phase I - Systems Analysis Framework

By

CYRUS WM. RICE DIVISION
NUS CORPORATION
PITTSBURGH, PENNSYLVANIA 15220

In Cooperation With

CONSULTEC, INC.
ROCKVILLE, MARYLAND 20850

GURNHAM, BRAMER, AND ASSOCIATES, INC.
McMURRAY, PENNSYLVANIA 15317

JENNINGS, STROUSS AND SALMON
WASHINGTON, D. C. 20006

For The

FEDERAL WATER QUALITY ADMINISTRATION
DEPARTMENT OF THE INTERIOR

PROGRAM NO. 16090 DBJ
CONTRACT NO. 14-12-476

August, 1970

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

1 Accession Number: W71-01264

2 Subject Field & Group: 06A 07A ~~07C~~ ~~06B~~ ~~07B~~ 5A

5 Organization: NUS Corporation, Pittsburgh, Pa., Cyrus Wm. Rice Division
~~Federal Water Pollution Control Administration~~

6 Title: DESIGN OF WATER QUALITY SURVEILLANCE SYSTEMS - PHASE I -
Systems Analysis Framework

10 Author(s):
Morgan, Paul V.
Johnson, Brownie R.
Bramer, Henry C.
Duncan, Wallace L.

11 Date: ~~February, 1970~~

12 Pages: ~~303~~

15 Contract Number: FWQA Contract 14-12-476

16 Project Number: FWQA Program 16090DBJ

21 Note: ~~house as 191 95 675, $3. in paper copy, .9 in microfiche.~~

22 Citation: ~~Report No.~~ 16090 DBJ 08/70 Water Pollution Control Research Series, ~~F.W.P.C.A.~~ February 1970. 303p, 5 tab, 14 fig, 306 ref, 5 append.

23 Descriptors (Starred First):
*Systems Analysis, *Water Quality, *Monitoring, *Legal Aspects, *Water Pollution, *Water Measurement, Water Quality Act, Water Quality Control, Water Quality Standards, Water Quality Criteria, Information Retrieval, Surveillance

25 Identifiers (Starred First): *Ohio River Basin, *Tennessee River Basin, Missouri River Basin, *Southeastern River Basins, *Systems Analysis Framework, Water Quality Monitors

27 Abstract

In order to accomplish the goals of the Water Quality Act of 1965, it is necessary to establish water quality surveillance systems throughout the nation. It is highly imperative that the individual systems developed by the various Federal, state, and interstate agencies be compatible and their data systems be interconnected. The various inputs and decisions necessary to accomplish this task are so complex that modern systems analysis techniques should be applied to insure that each of these water quality surveillance systems are developed and designed utilizing the same criteria. This study is the initial effort to apply systems analysis techniques to the solution of this problem. Three major river basins were selected for this study in order to identify the parameters common to any basin throughout the nation. The three basins were studied by: (1) reviewing the literature associated with their water quality characteristics; (2) on-site visits to the river basin areas; (3) comparative review of the interstate water quality standards and plans of implementation; and (4) legal considerations in surveillance program design. These tasks provided the input material to develop a systems analysis framework. The systems analysis framework was applied manually to select sites for water quality surveillance stations on the major streams studied within the three river basins. ~~This report was submitted in fulfillment of Program No. 16090DBJ and Contract No. 14-12-476 between the Federal Water Pollution Control Administration and the Cyrus Wm. Rice Division, NUS CORPORATION.~~

This report contains 306 references.

Abstractor: Paul V. Morgan
Institution: C. W. Rice Div.-NUS CORPORATION

SuDoc I 67.13/4:16090DBJ08/70

WR:102 (REV. OCT. 1968)
WRSIC

SEND TO: WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D.C. 20240

GPO: 1969-324-44

☆ U. S. GOVERNMENT PRINTING OFFICE : 1970 O - 403-762

BLANK PAGE

FWPCA REVIEW NOTICE

This report has been reviewed by the Federal Water Pollution Control Administration and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Federal Water Pollution Control Administration, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

In order to accomplish the goals of the Water Quality Act of 1965, it is necessary to establish water quality surveillance systems throughout the nation. It is highly imperative that the individual systems developed by the various Federal, state, and interstate agencies be compatible and their data systems be interconnected. The various inputs and decisions necessary to accomplish this task are so complex that modern systems analysis techniques should be applied to insure that each of these water quality surveillance systems are developed and designed utilizing the same criteria. This study is the initial effort to apply systems analysis techniques to the solution of this problem. Three major river basins were selected for this study in order to identify the parameters common to any basin throughout the nation. The three basins were studied by: (1) reviewing the literature associated with their water quality characteristics; (2) on-site visits to the river basin areas; (3) comparative review of the interstate water quality standards and plans of implementation; and (4) legal considerations in surveillance program design. These tasks provided the input material to develop a systems analysis framework. The systems analysis framework was applied manually to select sites for water quality surveillance stations on the major streams studied within the three river basins. This report was submitted in fulfillment of Program No. 16090DBJ and Contract No. 14-12-476 between the Federal Water Pollution Control Administration and the Cyrus Wm. Rice Division, NUS CORPORATION.

Key Words: Systems Analysis, Water Quality, Monitoring, Legal Aspects, Water Pollution, Water Measurement, Water Quality Act, Water Quality Control, Water Quality Standards, Water Quality Criteria, Information Retrieval, Surveillance, Ohio River Basin, Tennessee River Basin, Missouri River Basin, Southeastern River Basins, Systems Analysis Framework, Water Quality Monitors.

CONTENTS

Page

ABSTRACT.. iii

FIGURES... ix

TABLES.. x

SECTION 1 - CONCLUSIONS AND RECOMMENDATIONS........... 1

SECTION 2 - PROJECT DESIGN............................ 7

STUDY OBJECTIVES.................................. 7

PLAN OF RESEARCH.................................. 7

WATER QUALITY CONSIDERATIONS...................... 14
  Sources of Pollution............................ 15
  Criteria for Water Uses......................... 17

SURVEILLANCE PROGRAMS............................. 25
  General Considerations.......................... 25
  FWPCA Mission................................... 26

SECTION 3 - DATA ACQUISITION FOR SURVEILLANCE PROGRAMS DESIGN...................................... 27

DATA SOURCES...................................... 27
  Governmental Agency Documents................... 27
  Technical Literature............................ 28
  On-Site Inspection of the River Basins.......... 28

DATA HANDLING AND RETRIEVAL....................... 30
  Indexing and Retrieval of Published Data........ 31
  STORET Inquiries................................ 32
  Site Inspection Data Handling and Retrieval..... 34
  Indexing Guide.................................. 35

SECTION 4 - LEGAL PROBLEMS INVOLVED IN THE ESTABLISHMENT OF A FEDERAL WATER QUALITY SURVEILLANCE SYSTEM......................... 42

STATUTORY AUTHORITY FOR THE ESTABLISHMENT OF A FEDERAL WATER QUALITY SURVEILLANCE SYSTEM........... 42

CONTENTS (Cont.)

Page

ACQUISITION OF SITES FOR SURVEILLANCE STATIONS...... 52
Site Acquisition Under the Navigational Servitude.. 52
Establishment of Surveillance Stations on Federal Land.. 57
Acquisition of Surveillance Sites from States, Municipalities or Private Owners................ 63
Site Acquisition under H.R. 4148 and S. 7 and Recommended Legislation........................ 72

ADMISSIBILITY OF EVIDENCE COLLECTED BY SCIENTIFIC EQUIPMENT AND TRANSMITTED BY TELEMETRY DEVICES...... 74
General.. 75
Specific Requirements.. 76
Suggestions.. 80

MISCELLANEOUS.. 80

SUMMARY OF LEGAL CONSIDERATIONS........................ 84

SUGGESTED AMENDMENT.. 85

SECTION 5 - SYSTEMS ANALYSIS APPROACH TO SURVEILLANCE PROGRAM DESIGN........................ 87

THE SYSTEMS APPROACH CONCEPT........................ 87

SYSTEMS ANALYSIS FRAMEWORK FOR SURVEILLANCE SYSTEMS PROGRAMS.. 91
Generalized Framework.. 96
Lifetime Operational Concept........................ 96
System Design and Performance Characteristics..... 100
Development and Test Concept........................ 103
Training Concept.. 105
Facilities Survey.. 106
Manufacturing Concept.. 108
Threat Concept.. 110
Stress Conditions and Emergency Buildup Concept... 110
System Effectiveness.. 112
Logistic Support Concept........................ 114
Surveillance Station Locations Selection.......... 118
Data Flow in Surveillance Programs................ 135
Frequency of Measurement........................ 136

CONTENTS (Cont.)

Page

SECTION 6 - SURVEILLANCE PROGRAMS DESIGN 139

- IMPLEMENTATION OF THE SYSTEMS APPROACH 139
  - Input Information Requirements 139
  - Sensitivities of Design Considerations 141
  - Criteria for the Selection of Water Quality Surveillance Stations 141
  - Parameters and Frequency of Measurements 143
  - Selection of Water Quality Surveillance Stations 145
    - Ohio and Tennessee River Basins 145
    - Southeastern River Basins 149
    - Lower Missouri River Basins 152

SECTION 7 - ACKNOWLEDGMENTS 158

SECTION 8 - REFERENCES 159

SECTION 9 - APPENDICES 185

RIVER BASIN DATA AND STANDARDS

APPENDIX I - OHIO RIVER BASIN 185

- River Basin Descriptions 185
  - Ohio River 185
  - Tennessee River 188
  - Wabash River 189
  - Kanawha River 190
  - Monongahela River Basins 191
  - Allegheny River Basins 194
- Interstate Water Quality Standards 195
  - Ohio River 195
  - Tennessee River 208
  - Wabash River 215
  - Kanawha River 216
  - Allegheny River Basins 217
  - Monongahela River Basins 221

APPENDIX II - SOUTHEASTERN RIVER BASINS 228

- River Basin Descriptions 228
  - Ochlockonee River 228
  - Apalachicola River 229
    - Flint River 230
    - Spring Creek 231

CONTENTS (Cont.)

Page

Chattahoochee River.............................. 231
Choctawhatchee River............................. 231
Yellow River..................................... 232
Escambia River................................... 232
Conecuh River.................................... 233
Perdido River.................................... 233
Mobile River..................................... 234
Alabama River.................................... 235
Tombigbee River.................................. 235
Black Warrior River.............................. 236
Pascagoula River................................. 237
Pearl River...................................... 238
Interstate Water Quality Standards............... 239
Ochlockonee River................................ 239
Apalachicola River............................... 240
Chattahoochee River.............................. 241
Flint River...................................... 246
Choctawhatchee River............................. 247
Yellow River..................................... 248
Escambia River................................... 248
Conecuh River.................................... 251
Perdido River.................................... 253
Mobile River..................................... 254
Alabama River.................................... 257
Tombigbee River.................................. 259
Pascagoula River................................. 261
Pearl River...................................... 263

APPENDIX III - LOWER MISSOURI RIVER BASIN........... 269

River Basin Descriptions......................... 269
Lower Missouri River............................. 269
Osage River...................................... 271
Marais des Cygnes River.......................... 271
Little Osage River............................... 271
Kansas River..................................... 271
Republican River................................. 272
Smoky Hill River................................. 272
Platte River..................................... 273
South Platte River............................... 274
North Platte River............................... 276
Niobrara River................................... 277
Water Quality Standards.......................... 277
Missouri River................................... 277

CONTENTS (Cont.)

Page

Osage River.................................... 284
  Marais des Cygnes River...................... 284
  Little Osage River........................... 284
Kansas River................................... 286
  Smoky Hill River............................. 287
  Republican River............................. 288
Platte River................................... 292
  South Platte River........................... 292
  North Platte River........................... 294
Niobrara River................................. 297

FIGURES

Page

1. Task One of the Project.......................... 9
2. Task Two of the Project.......................... 13
3. Task Three of the Project........................ 15
4. Task Four of the Project......................... 16
5. Operation of Information Retrieval System........ 33
6. Steps Within the Systems Approach................ 90
7. Generalized Systems Analysis Framework........... 93
8. Analytical Framework for Selecting Surveillance Station Locations.................................. 94
9. Data Flow in the Surveillance System............. 119
10. Analytical Framework for Determining the Frequency of Measurement......................... 137
11. Map of the Study Area............................ 300
12. Ohio and Tennessee River Basins.................. 301
13. Southeastern River Basins........................ 302
14. Lower Missouri River Basin....................... 303

TABLES

Page

1. Surface Water Criteria for Public Water Supplies.. 18

2. Summary of Specific Quality Characteristics of Surface Waters that have been used as Sources for Industrial Water Supplies.................... 19

3. Suggested Guidelines for Salinity in Irrigation Water.. 22

4. Key Water Quality Criteria for Farmstead Uses..... 23

5. Water Quality Criteria for Recreational Uses...... 24

BLANK PAGE

SECTION 1

CONCLUSIONS AND RECOMMENDATIONS

This study has elucidated the significant parameters which describe a water quality surveillance network system.

These factors were then applied in their relevant importance and interrelationships of the factors have been shown through a systems analysis framework.

Inadequacies of existing data have been pointed up.

Available information has been used to locate monitors on only those streams as specified in the proposal. This was done with full reality that this would allow gaps in the monitoring network.

Specific rationales were isolated from the generalized systems analysis framework as developed. These provided (1) an analytical format for selecting surveillance station locations, (2) data flow in the surveillance system, and (3) frequency of measurement.

The FWPCA has received charges from the Congress in three general areas related to water quality surveillance. The first of these is to monitor the interstate streams of the nation and to provide reliable data from which the extent of compliance with the interstate water quality standards can be assessed. The second charge is to provide reliable data which will indicate long-term trends and overall changes in water quality. The third is to provide an evaluation of information to the Congress from which the effectiveness of legislative programs can be evaluated and guidance provided for the optimum utilization of appropriated funds.

It is highly important at this early stage of the development of water quality surveillance systems that they be integrated in such a fashion that specifications are uniform as to the quality of data to be obtained and uniform so as to insure system compatibility. Previous systems have become ineffective because of lack of coordination.

The spectrum of water quality surveillance systems across this country is broad. At one end of the spectrum are surveillance systems similar to those of ORSANCO. These utilize electronic monitors measuring several chemical and physical parameters and are interconnected by sophisticated data transmission systems. Such a system provides not only real time data, but can be used to demonstrate long-term trends and to predict short-term water quality changes. On the other end of the spectrum are systems where water quality surveillance is nothing more exotic than a man with a bucket. If the required job is to be done, it is necessary that adequate water quality surveillance systems be developed.

A number of legal problems will be involved in the establishment of a Federal water quality surveillance system for the three river basins designated in this study.

Legal questions involving first the statutory authority for the establishment and implementation of a Federal surveillance system were addressed. Additional legal questions addressed included (1) the establishment of surveillance stations under the authority of the navigation servitude; (2) the statutory authority for land acquisition for the surveillance system; (3) the establishment of stations on various classes of Federal land pursuant to Federal statute; (4) the types of interests in lands which should be acquired; (5) the evidentiary problems which will be involved in utilizing data and information developed in operation of the surveillance system in water pollution abatement and enforcement proceedings; (6) the potential liability of the United States to private individuals for damages caused by the system; and (7) the liability of private individuals for damages to the surveillance stations or equipment.

The present research project has provided opportunities for appraisal of the various aspects of water quality surveillance programs. The following recommendations are made on the basis of the work completed in the course of the project and are generally supported by detailed information in the body of the final report.

A single agency should serve to coordinate the pollution evaluation related water quality surveillance activities of all Federal, state, and interstate agencies. The FWPCA seems to be the appropriate agency to fulfill this function. Surveillance systems development and standardization, as well as primary data-handling responsibility, should lie with this single agency.

Water quality data from whatever source should be made available for incorporation into the STORET system. Such data should, in turn, be made freely available to local or regional interested parties.

The FWPCA should encourage research and development programs leading to the development of better water quality surveillance monitoring systems. Whether these systems be automated wet chemical analyses, electronic probes, or other means, the research and development leadership should become a major role of the FWPCA. For too long, most of the effort has been directed toward writing specifications for such systems rather than encouragement of original R&D efforts. A joint governmental-industrial program is needed to assemble the required technology in this area.

The FWPCA should sponsor research to evaluate, on a cost-effectiveness basis, the water quality surveillance methods used today. These should include the use of manual sampling, automated sampling techniques, and automated monitoring techniques. It is necessary to have better data in order that proper choices may be made based upon total costs of the various methods capable of providing reliable data.

The FWPCA should encourage the utilization of some of the more technologically advanced systems which are being brought to bear on such problems of today. Among these are the use of aircraft in water quality surveillance; such uses include both remote observation and sample collection. These techniques are not new. Although there have been many literature citations to their use, they are not widely used. The routine use of aircraft for water quality surveillance should be encouraged; a much better appreciation of a total watershed can be gained from an aircraft. In bygone days, only the helicopter could supply both the capability to remotely observe and to sample a stream. A fixed winged aircraft demonstrated recently the ability of a modern line and winch arrangement to collect stream samples during a record flood which was an aftermath of hurricane Camille.

The FWPCA should sponsor greater utilization of satellites, as well as high altitude aircraft to provide both color and infrared imagery. Such use could develop considerable water quality surveillance information for broad regions of the country. Coordination of this type of information with other surveillance data could fill many of the gaps which have existed in our surveillance systems.

The FWPCA should improve the overall effectiveness of the STORET system. This system has great potential, however, it is under-utilized at the present time. Much of the water quality information which is collected never finds its way into STORET. A program should be developed in which STORET should receive all of the data being collected across the country, on as close to a real time basis as possible.

STORET should also be improved so that it can handle the vast amounts of data from current and future systems. FWPCA should incorporate feedback systems into STORET to provide not only the data, but visual display and alarm systems which should make evaluation andinterpretation of the data nearly instantaneous.

The systems analysis framework developed in this project should be implemented by assembling all input data for a single river watershed. The tasks, functions, and interrelationships as identified in the systems analysis framework should be described in specific quantitative relationships. This application should be expanded to a multi-basin area in order to utilize the potential of the systems analysis framework as developed. Where possible, these quantitative relationships should be treated by computer techniques. A user handbook, either manually or computer related, should be developed to describe these techniques and extend their utility.

Two classes of water quality monitoring surveillance stations have been selected for each of the three river basins studied in the project. The Class I monitoring sites are of greater importance than the Class II sites.

The Class I sites should be equipped with automatic monitoring and sampling equipment. They should be integrated into a telemetry network to increase their utility. The Class II stations are of lesser importance and should be sampled at a monthly frequency. The data collected should be analyzed statistically and then further decisions concerning equipment and frequency of sampling could be made.

The quality of data should be readily determinable as compared with the current edition of "Standard Methods" and/or the "FWPCA Methods for Chemical Analysis of Water and Wastes." Data which does not attain these standards should be used but so identified.

It is concluded that the establishment of a Federal water quality surveillance system is necessary and useful in implementing the objectives of the Water Pollution Control laws. Though not specifically authorized by existing laws, the establishment of surveillance facilities is authorized in the general context of the applicable statute, the Federal Water Pollution Control Act, 70 Stat. 498 (1956), as amended, 33 U.S.C., p 466 et seq. (1964). A clearer authority was included in the Water Quality Improvement Act of 1970.

Where surveillance sites can be located below the high water mark on navigable streams, it may be possible for the United States to do so without payment of compensation pursuant to the navigation servitude vested in the Federal Government.

Where it is desired to establish stations on Federal lands, many inter-departmental and intra-departmental obstacles may make acquisition of proper sites no more feasible or economical than acquisition of sites on state or private lands. It must be noted, also, that mere Federal ownership of potential sites does not guarantee the use of that site for surveillance purposes. Nevertheless, Federal lands frequently offer many advantages over state or private lands, and should be considered carefully in site selection.

In regard to the establishment of surveillance stations on state or private lands, it is concluded that no statutory authority exists for the acquisition of sites. In fact, the existing Federal Water Pollution Control Act, as amended, is deficient in several important respects: (1) specific authority for site acquisition; (2) procurement of material; and (3) statutory authority for the admissibility of data developed in enforcement and abatement proceedings. Such deficiencies will not be remedied by pending amendments to the Act. H.R. 4148 and S.7, but will require augmentation by supplemental legislation. A draft of prepared legislation designed to provide specifically for the establishment of a water quality surveillance system and for the acquisition of the necessary sites for surveillance stations is set forth in the Appendix to this report.

In the light of the fact that the existing law places much of the initial responsibility for enforcement and abatement on the state water pollution control agencies, the Federal water quality surveillance system should be developed in close consultation with cognizant state agencies and officials to minimize the duplicity of facilities and activities. It is desirable that any new legislation specifically assign responsibility or provide for coordination of activities in the operation of water quality surveillance facilities.

With respect to the use of data and information developed by surveillance facilities in administrative and judicial proceedings for abatement and enforcement, the applicable evidentiary requirements pose no insuperable barrier to the introduction of such data and information in evidence. Applicable evidentiary requirements should be considered, however, in the design, construction, and operation of Federal water quality surveillance facilities.

SECTION 2

PROJECT DESIGN

With the enactment of the Water Quality Act of 1965, the Federal Government became even more firmly committed to the attainment of clean water in the United States. The Water Quality Standards, submitted by the States and approved by the Secretary of the Interior, have established the desired water uses, the necessary water quality for these uses, and plans for the implementation of the required pollution abatement measures. It is necessary, however, that water quality be continually ascertained in a reliable and timely manner if the objective of the Standards are to be realized. The surveillance programs of the FWPCA seek to insure that these objectives are attained.

STUDY OBJECTIVES

The objectives of this study have been to evaluate and assist in the future development of the FWPCA surveillance programs through case studies in major river basins and to develop a generalized method for the optimum design of such programs. Specific objectives have been:

Study of three river basins to determine present water quality, present and projected water uses, and the Water Quality Standards with Plans of Implementation and Enforcement.

Preparation of a system analysis framework for the general design of a surveillance program.

Definition of specific criteria for establishment of surveillance programs using the systems analysis framework.

Presentation of plans for the establishment of surveillance programs in the three example basins.

PLAN OF RESEARCH

The objectives of the study have been realized through research activities outlined below as a series of tasks.

Task 1 Analysis of the three specific river basins to determine the water quality, present and projected water uses, water quality standards, and plans for implementation and enforcement. The basins studied were the Ohio River Basin, the lower Missouri River Basin, and those Southeastern river basins draining into the Gulf of Mexico (See Figures 1 and 11).

Selection of the river basins to be used as source material for this project was begun in the proposal stages of the study. The river basins finally selected were the result of conferences between RICE personnel and FWPCA headquarters and regional office personnel. The area was narrowed down to portions of three major river basins. Each of these basins had a particular facet in its makeup, which would allow the knowledge gained by its study to be reapplied to other basins within the United States. A number of the factors which determined the selection of these basins follows:

The Southeastern River Basins draining into the Gulf of Mexico. They have common features such as semi-tropical climate, estuaries that reach the Gulf of Mexico, shellfish industry, and many large reservoirs and water power projects.

The Ohio River Basin drains a highly industrialized and heavily populated area. It also contains agricultural, mining, and oil wastes. It is subject to flooding and has many control dams as well as many navigational locks and dams.

The Lower Missouri River Basin drains an area where water is used for irrigation, agriculture and cattle feedlots. The rivers in the basin have high turbidity with salinities approaching the limits of the PHS Drinking Water Standards.

It is apparent that each of these basins has been selected to be representative of distinct areas which would require different types of surveillance programs, and which require varied water quality standards, plans of implementation, and enforcement schedules.

A general description of the waters in each of the three basins considered in this study is as follows:

Southeastern River Basins

The rivers and tributaries to be included in those of the Southeastern River Basins draining into the Gulf of Mexico are:

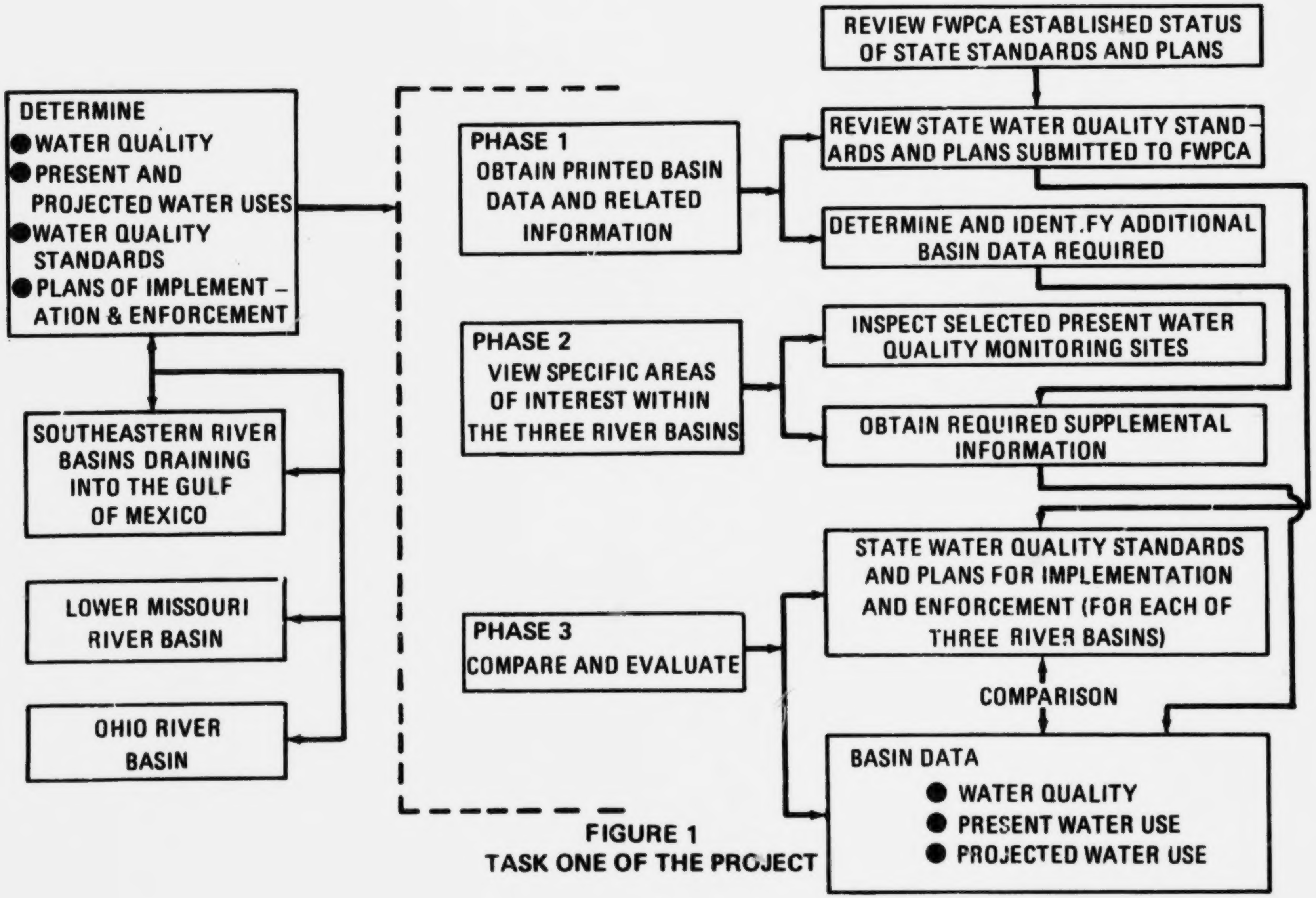

DETERMINE
● WATER QUALITY
● PRESENT AND PROJECTED WATER USES
● WATER QUALITY STANDARDS
● PLANS OF IMPLEMENTATION & ENFORCEMENT
SOUTHEASTERN RIVER BASINS DRAINING INTO THE GULF OF MEXICO
LOWER MISSOURI RIVER BASIN
OHIO RIVER BASIN
PHASE 1
OBTAIN PRINTED BASIN DATA AND RELATED INFORMATION
PHASE 2
VIEW SPECIFIC AREAS OF INTEREST WITHIN THE THREE RIVER BASINS
PHASE 3
COMPARE AND EVALUATE
REVIEW FWPCA ESTABLISHED STATUS OF STATE STANDARDS AND PLANS
REVIEW STATE WATER QUALITY STANDARDS AND PLANS SUBMITTED TO FWPCA
DETERMINE AND IDENTIFY ADDITIONAL BASIN DATA REQUIRED
INSPECT SELECTED PRESENT WATER QUALITY MONITORING SITES
OBTAIN REQUIRED SUPPLEMENTAL INFORMATION
STATE WATER QUALITY STANDARDS AND PLANS FOR IMPLEMENTATION AND ENFORCEMENT (FOR EACH OF THREE RIVER BASINS)
COMPARISON
BASIN DATA
● WATER QUALITY
● PRESENT WATER USE
● PROJECTED WATER USE

FIGURE 1
TASK ONE OF THE PROJECT

The Ochlockonee River which drains into the Gulf of Mexico at Apalachee Bay in Western Florida and its tributaries which flow from Southwestern Georgia.

The Apalachicola River and its tributaries, the Flint River, Spring Creek, and the Chattahoochee River, which drain into the Gulf of Mexico via Apalachicola Bay.

The Choctawhatchee River and its tributaries which flow from Southeastern Alabama into Western Florida and drain into the Gulf of Mexico via Choctawhatchee Bay.

The Yellow River and its tributaries which originate in Southeastern Alabama and flow into Pensacola Bay via East Bay in Western Florida and on to the Gulf of Mexico.

The Escambia River empties into Pensacola Bay via Escambia Bay. This stream originates in Southcentral Alabama and flows southernly across Alabama into the Florida Panhandle.

The Mobile River and its tributaries, the Alabama River, the Tombigbee River and the Black Warrior River which flow into the Gulf of Mexico via Mobile Bay.

The Pascagoula River empties into the Gulf of Mexico at Mississippi Sound. It and its tributaries drain an area of Southeastern Mississippi. Much of this river basin is devoted to cotton production.

The Pearl River originates in Eastcentral Mississippi and flows south to enter the Gulf of Mexico via Mississippi Sound.

Ohio River Basin

The rivers and tributaries which were studied in the Ohio River Basin are as follows:

The Ohio River which is formed at the junction of the Monongahela and the Allegheny Rivers at Pittsburgh, Pennsylvania and flows southwest for 981 miles to its confluence with the Mississippi River at Cairo, Illinois.

The Allegheny River is 325 miles long, and has its headwaters in Northcentral Pennsylvania. It flows into New York, for a brief stretch and then re-enters Central Pennsylvania and flows south to Pittsburgh.

The Monongahela River and its tributaries, the Youghiogheny River, the Cheat River, the Tygart River and West Fork River.

The Kanawha River flows through Westcentral West Virginia for 97 miles and joins the Ohio River at Point Pleasant, Ohio.

The Wabash River drains the southern portions of Illinois and Indiana. It is 475 miles long and enters the Ohio River approximately 35 miles below Evansville, Indiana.

The Tennessee River is the largest tributary of the Ohio River. It is approximately 652 miles long and joins the Ohio River at Paducah, Kentucky. The Tennessee River drains areas of Kentucky, Tennessee and Alabama.

Lower Missouri River Basin

The rivers and tributaries to be included in those of the Lower Missouri River Basin are as follows:

The Missouri River is one of the principle rivers of the United States. Its length is approximately 2466 miles. It is a major tributary of the Mississippi River and is the master stream in the Northern plains of the United States. The lower Missouri River Basin drains Southeastern Wyoming, Northeastern Colorado, all of Nebraska, Kansas, Missouri and Western Iowa.

The area of interest begins with the Niobrara River, which joins the Missouri River at Niobrara, Nebraska. This is approximately 35 miles upstream from the Gavin's Point Dam, which is one of a series of dams on the main stem of the Missouri River. The Gavin's Point Dam forms the Lewis & Clark Lake.

The Niobrara River has its origin near the Northwestern tip of Nebraska although portions of it are regarded as temporary streams in Eastern Wyoming. It flows almost due east and drains part of Northern Nebraska along the South Dakota border.

The Platte River is a 310 mile long tributary of the Missouri River. It is formed by the junction of the North Platte and the South Platte Rivers at North Platte, Nebraska.

The South Platte River originates in Central Colorado. It flows east from the mountains to a few miles south of Denver and then flows north to Denver and later east to join the North Platte in Nebraska.

The North Platte River originates in Northern Colorado. It flows north into Wyoming and then to the east where it enters Nebraska.

The Kansas River is formed in Central Kansas by the junction of the Smoky Hill and Republican Rivers. It flows east and joins with the Missouri River at Kansas City.

The Osage River is a 400 mile long tributary of the Missouri River. It is formed by the junction of the Marais des Cygnes River and the Little Osage River in East Central Kansas. It joins the Missouri River nine miles east of Jefferson City.

This task was further subdivided into three subtasks:

Subtask 1 - Evaluation of related and available printed basin data relating to water quality. Review of information including the Federal Water Pollution Control Administration established standards and criteria, the pertinent water quality standards and plans, and additional basin data required for quality surveillance analysis purposes.

Subtask 2 - Analysis of specific points of interest within the three river basins. The analysis included an on-site inspection of selected water quality monitoring sites with the objectives of acquiring supplemental information to that available from published materials.

Subtask 3 - Comparison and evaluation of state water quality standards and plans for surveillance implementation and enforcement versus specific river basin data studied on water quality, current water uses and projected usage.

Task 2 Development of a systems analysis framework to evaluate the data obtained in Task 1 for the three river basins. The framework addresses three primary elements integrated in a manner which enables the assessment of impact to the total system through incremental variation in any one element. The elements are: (a) water quality measurement, (b) the flow of water quality data including methods of collection, analysis, and data transmission and storage, (c) the present and projected uses of the water and stored data. Figure 2 illustrates the considerations inherent to the systems approach.

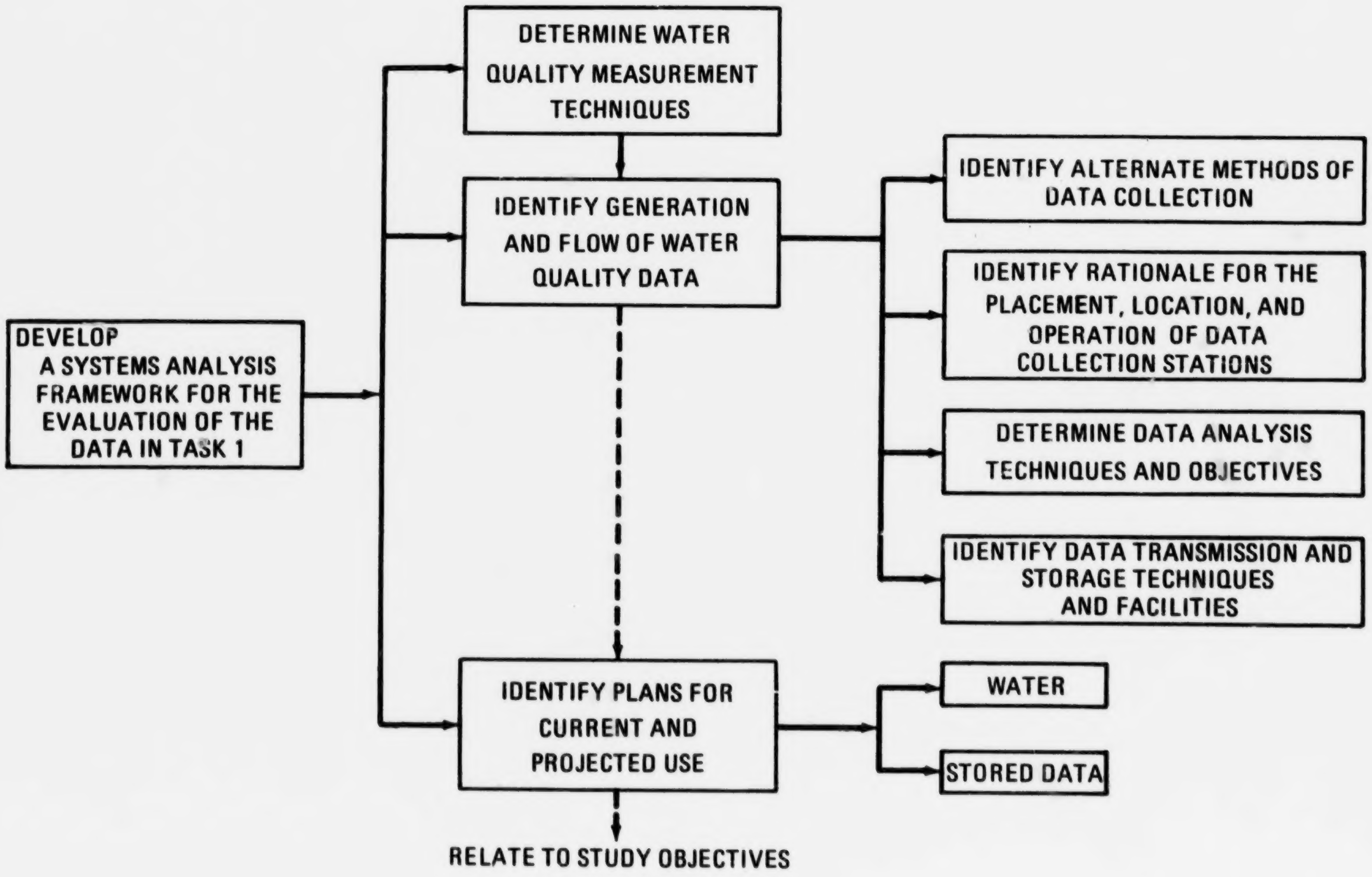

DEVELOP A SYSTEMS ANALYSIS FRAMEWORK FOR THE EVALUATION OF THE DATA IN TASK 1
DETERMINE WATER QUALITY MEASUREMENT TECHNIQUES
IDENTIFY GENERATION AND FLOW OF WATER QUALITY DATA
IDENTIFY PLANS FOR CURRENT AND PROJECTED USE
IDENTIFY ALTERNATE METHODS OF DATA COLLECTION
IDENTIFY RATIONALE FOR THE PLACEMENT, LOCATION, AND OPERATION OF DATA COLLECTION STATIONS
DETERMINE DATA ANALYSIS TECHNIQUES AND OBJECTIVES
IDENTIFY DATA TRANSMISSION AND STORAGE TECHNIQUES AND FACILITIES
WATER
STORED DATA
RELATE TO STUDY OBJECTIVES

FIGURE 2
TASK TWO OF THE PROJECT

Task 3 Definition of the criteria for the establishment of water quality surveillance systems within each of the three basins using the analysis framework discussed in Task 2. Specifically, the following considerations were investigated. (See Figure 3)

Station Location
The method and parameters to consider in locating water quality surveillance stations.

Data Type
Method and parameters to determine the type of data to be collected.

Sample Collection
Method and considerations to select an appropriate sample collection system.

Analytical System
Method and parameters to consider in selecting an analytical system.

Data Transmission
Method and considerations inherent to the selection of a data transmission system.

Data Handling
Method and parameters to consider in the selection of a data handling and dissemination system.

Task 4 Preparation of a plan for the establishment of water quality surveillance programs for each of the three river basins. Figure 4 presents the objectives for this task.

WATER QUALITY CONSIDERATIONS

The criteria for the various water uses establish the permissible levels of pollutants in the surface waters at particular locations.

Sources of Pollution

In general, the quality of surface waters is determined by two major factors: the mineral structure of the geological strata and the chemistry of the surface soils. The quality of surface waters is also affected by agricultural, industrial, and municipal wastes. The effects of mineral

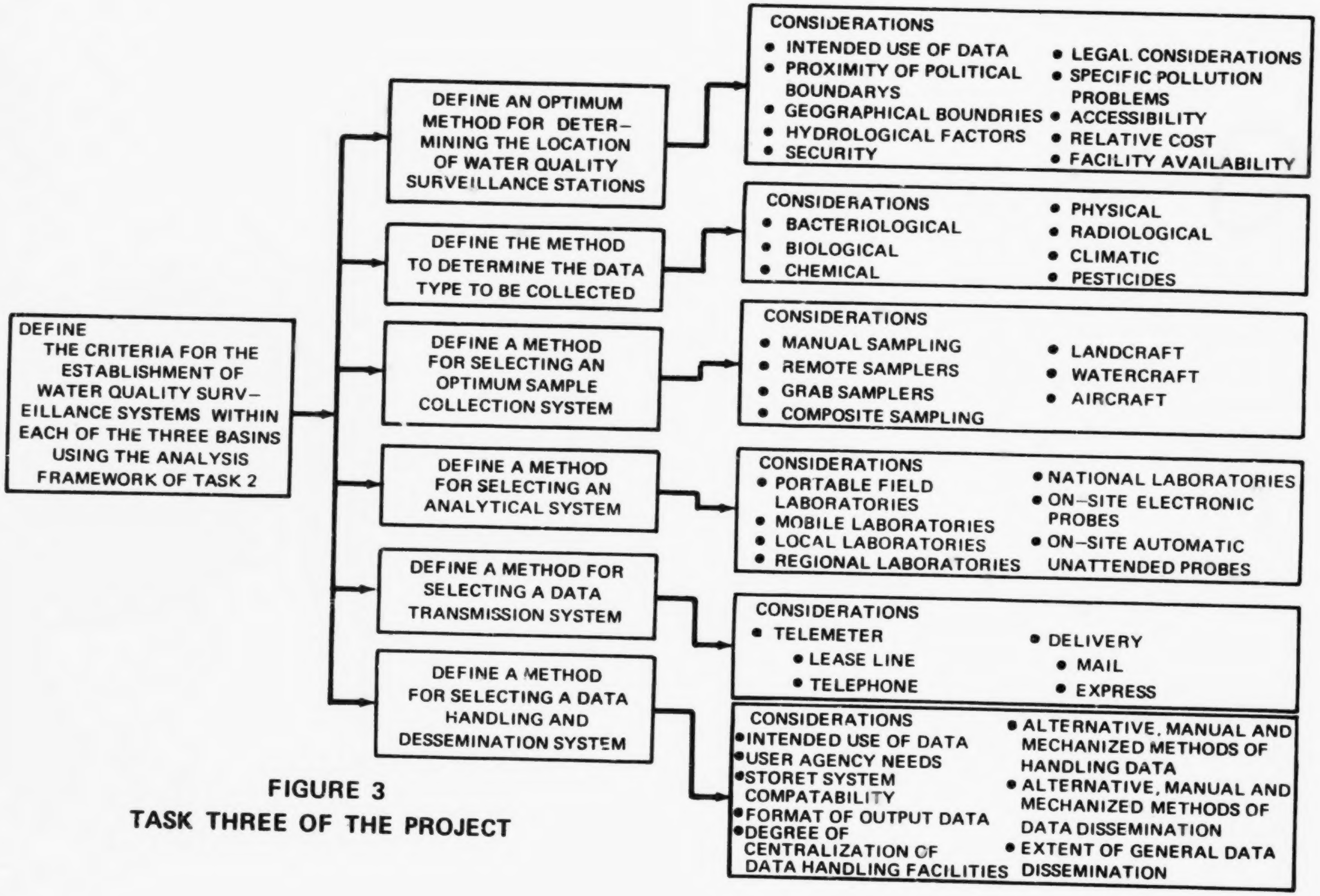

DEFINE THE CRITERIA FOR THE ESTABLISHMENT OF WATER QUALITY SURVEILLANCE SYSTEMS WITHIN EACH OF THE THREE BASINS USING THE ANALYSIS FRAMEWORK OF TASK 2
DEFINE AN OPTIMUM METHOD FOR DETERMINING THE LOCATION OF WATER QUALITY SURVEILLANCE STATIONS
CONSIDERATIONS
• INTENDED USE OF DATA
• PROXIMITY OF POLITICAL BOUNDARYS
• GEOGRAPHICAL BOUNDRIES
• HYDROLOGICAL FACTORS
• SECURITY
• LEGAL CONSIDERATIONS
• SPECIFIC POLLUTION PROBLEMS
• ACCESSIBILITY
• RELATIVE COST
• FACILITY AVAILABILITY
DEFINE THE METHOD TO DETERMINE THE DATA TYPE TO BE COLLECTED
CONSIDERATIONS
• BACTERIOLOGICAL
• BIOLOGICAL
• CHEMICAL
• PHYSICAL
• RADIOLOGICAL
• CLIMATIC
• PESTICIDES
DEFINE A METHOD FOR SELECTING AN OPTIMUM SAMPLE COLLECTION SYSTEM
CONSIDERATIONS
• MANUAL SAMPLING
• REMOTE SAMPLERS
• GRAB SAMPLERS
• COMPOSITE SAMPLING
• LANDCRAFT
• WATERCRAFT
• AIRCRAFT
DEFINE A METHOD FOR SELECTING AN ANALYTICAL SYSTEM
CONSIDERATIONS
• PORTABLE FIELD LABORATORIES
• MOBILE LABORATORIES
• LOCAL LABORATORIES
• REGIONAL LABORATORIES
• NATIONAL LABORATORIES
• ON–SITE ELECTRONIC PROBES
• ON–SITE AUTOMATIC UNATTENDED PROBES
DEFINE A METHOD FOR SELECTING A DATA TRANSMISSION SYSTEM
CONSIDERATIONS
• TELEMETER
• LEASE LINE
• TELEPHONE
• DELIVERY
• MAIL
• EXPRESS
DEFINE A METHOD FOR SELECTING A DATA HANDLING AND DESSEMINATION SYSTEM
CONSIDERATIONS
• INTENDED USE OF DATA
• USER AGENCY NEEDS
• STORET SYSTEM COMPATABILITY
• FORMAT OF OUTPUT DATA
• DEGREE OF CENTRALIZATION OF DATA HANDLING FACILITIES
• ALTERNATIVE, MANUAL AND MECHANIZED METHODS OF HANDLING DATA
• ALTERNATIVE, MANUAL AND MECHANIZED METHODS OF DATA DISSEMINATION
• EXTENT OF GENERAL DATA DISSEMINATION

FIGURE 3
TASK THREE OF THE PROJECT

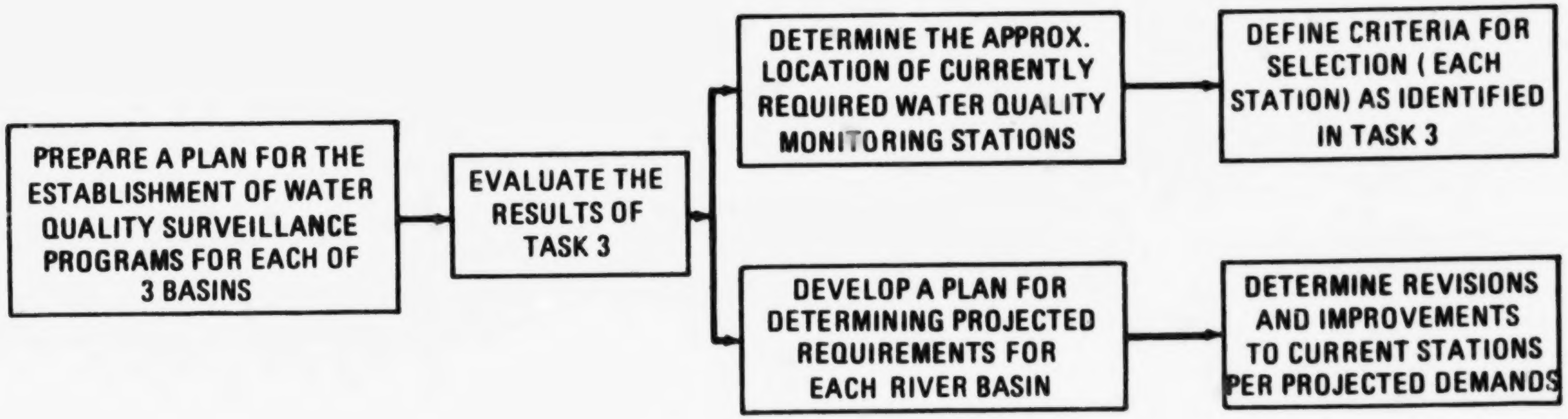

PREPARE A PLAN FOR THE ESTABLISHMENT OF WATER QUALITY SURVEILLANCE PROGRAMS FOR EACH OF 3 BASINS
EVALUATE THE RESULTS OF TASK 3
DETERMINE THE APPROX. LOCATION OF CURRENTLY REQUIRED WATER QUALITY MONITORING STATIONS
DEFINE CRITERIA FOR SELECTION (EACH STATION) AS IDENTIFIED IN TASK 3
DEVELOP A PLAN FOR DETERMINING PROJECTED REQUIREMENTS FOR EACH RIVER BASIN
DETERMINE REVISIONS AND IMPROVEMENTS TO CURRENT STATIONS PER PROJECTED DEMANDS

FIGURE 4
TASK FOUR OF THE PROJECT

and soil quality are almost uncontrollable by man at present, whereas he has the technical knowledge and engineering capabilities to control water quality efforts due to agricultural, industrial, and municipal pollution.

The agricultural uses of water add dissolved minerals, sediments, fertilizers, pesticides, chemicals, and herbicides to the surface waters. Industrial wastes and organic materials, inorganic ions, and suspended solids from cooling waters, process waters, and surface runoff from industrial plants or mines. Municipal wastes consist mainly of organic materials, suspended solids and associated bacteria; inorganics are often contributed by surface runoff to combined or separate storm sewers.

Criteria for Water Uses

Water pollution results when potential pollutants interfere with one or more water uses. The Water Quality Standards seek to establish the levels of pollutants in the surface waters which will allow the desired uses. Criteria for the various uses are different and involve values for both specific parameters and common parameters.

The water quality criteria for municipal water supplies may be predicated on the degree of treatment necessary to produce a palatable and safe finished water. Modern water treatment methods can produce a satisfactory finished water from literally any supply. The cost of treatment, however, is related to the quality of the supply and thus becomes the measure of pollution insofar as this use is concerned. Of greatest significance as quality parameters for this use are the concentrations of coliform bacteria, organic compounds that may result in tastes and odors, and of suspended matter. The relative effects of these and other quality measurements on the suitability of supplies for municipal use are shown in Table 1.

Industrial water uses include cooling, process water, boiler feedwater, and water for sanitary purposes. Quality criteria for industrial process water vary over a very wide range depending on the industry and the nature of the product. Industrial uses of water for cooling and for power are more or less common to all industries, and the applicable criteria are thus uniform. As in the case of water for municipal uses, the cost of treatment becomes a measure of pollution. Technologically, water from almost any source can be rendered suitable for any industrial use. See Table 2.

TABLE 1

SURFACE WATER CRITERIA FOR PUBLIC WATER SUPPLIES

Constituent or characteristic	Permissible Criteria	Desirable Criteria
PHYSICAL:		
Color (color units)	75	<10
Odor	Narrative	Virtually absent
Temperature	do	Narrative
Turbidity	do	Virtually absent
MICROBIOLOGICAL:		
Coliform organisms	10,000/100 ml	<100/100 ml
Fecal coliforms	2,000/100 ml	<20/100 ml
INORGANIC CHEMICALS:	(mg/l)	(mg/l)
Alkalinity	Narrative	Narrative
Ammonia	0.5 (as N)	<0.01
Arsenic	0.05	Absent
Barium	1.0	do
Boron	1.0	do
Cadmium	0.01	do
Chloride	250	<25
Chromium, hexavalent	0.5	Absent
Copper	1.0	Virtually absent
Dissolved oxygen	≥4 (monthly mean) ≥3 (individual sample)	Near saturation
Fluoride	Narrative	Narrative
Hardness	do	do
Iron (filterable)	0.3	Virtually absent
Lead	0.05	Absent
Manganese (filterable)	0.05	do
Nitrates plus nitrites	10 (as N)	Virtually absent
pH (range)	6.0-8.5	Narrative
Phosphorus	Narrative	do
Selenium	0.01	Absent
Silver	0.05	do
Sulfate	250	<50
Total dissolved solids (filterable residue)	500	<200
Uranyl ion	5	Absent
Zinc	5	Virtually absent
ORGANIC CHEMICALS:		
Carbon chloroform extract (CCE)	0.15	<0.04
Cyanide	0.20	Absent
Methylene blue active substances	0.5	Virtually absent
Oil and grease	Virtually absent	Absent
Pesticides:		
Aldrin	0.017	do
Chlordane	0.003	do
DDT	0.042	do
Dieldrin	0.017	do
Endrin	0.001	do
Heptachlor	0.018	do
Heptachlor epoxide	0.018	do
Lindane	0.056	do
Methoxychlor	0.035	do
Organic phosphate plus carbamates	0.1	do
Toxaphene	0.005	do
Herbicides:		
2,4-D plus 2,4,5-T, plus 2,4,5-TP	0.1	do
Phenols	0.001	do
RADIOACTIVITY:	(pc/l)	(pc/l)
Gross beta	1,000	<100
Radium-226	3	<1
Strontium-90	10	<2

Source is "Water Quality Criteria," FWPCA, 1968. See source for narrative discussion.

TABLE 2

SUMMARY OF SPECIFIC QUALITY CHARACTERISTICS OF SURFACE WATERS THAT HAVE BEEN USED AS SOURCES FOR INDUSTRIAL WATER SUPPLIES

(Unless otherwise indicated, units are mg/1 and values are maximums. No one water will have all the maximum values shown.)

	BOILER MAKEUP WATER		COOLING WATER				PROCESS WATER					
			Fresh		Brackish							
Characteristic	Industrial 0 to 1,500 psig	Utility 700 to 5,000 psig	Once Through	Makeup Recycle	Once Through	Makeup Recycle	Textile Industry SIC-22	Pulp and Paper Industry SIC-26	Chemical Industry SIC-28	Petroleum Industry SIC-29	Prim. Metals Industry SIC-33
Silica (SiO2)	150	150	50	150	25	25	----	50	----	50	----
Aluminum (Al)	3	3	3	3	----	----	----	----	----	----	----
Iron (Fe)	80	80	14	80	1.0	1.0	0.3	2.6	5	15	----
Manganese (Mn)	10	10	2.5	10	0.02	0.02	1.0	----	2	----	----
Copper (Cu)	----	----	----	----	----	----	0.5	----	----	----	----
Calcium (Ca)	----	----	500	500	1,200	1,200	----	----	200	220	----
Magnesium (Mg)	----	----	----	----	----	----	----	----	100	85	----
Sodium and potassium (Na+K)	----	----	----	----	----	----	----	----	----	230	----
Ammonia (NH3)	----	----	----	----	----	----	----	----	----	----	----
Bicarbonate (HCO3)	600	600	600	600	180	180	----	----	600	480	----
Sulfate (SO4)	1,400	1,400	680	680	2,700	2,700	----	----	850	570	----
Chloride (Cl)	19,000	19,000	600	500	22,000	22,000	----	200	500	1,600	500
Fluoride (F)	----	----	----	----	----	----	----	----	----	1.2	----
Nitrate (NO3)	----	----	30	30	----	----	----	----	----	8	----
Phosphate (PO4)	----	50	4	4	5	5	----	----	----	----	----
Dissolved solids	35,000	35,000	1,000	1,000	35,000	35,000	150	1,080	2,500	3,500	1,500
Suspended solids	15,000	15,000	5,000	15,000	250	250	1,000	----	10,000	5,000	3,000
Hardness (CaCO3)	5,000	5,000	850	850	7,000	7,000	120	475	1,000	900	1,000
Alkalinity (CaCO3)	500	500	500	500	150	150	----	----	500	----	200
Acidity (CaCO3)	1,000	1,000	0	200	0	0	----	----	----	----	75
pH, units	----	----	5.0-8.9	3.5-9.1	5.0-8.4	5.0-8.4	6.0-8.0	4.6-9.4	5.5-9.0	6.0-9.0	3-9
Color, units	1,200	1,200	----	1,200	----	----	----	360	500	25	----
Organics:											
Methylene blue active substances	2	10	1.3	1.3	----	1.3	----	----	----	----	----
Carbon tetrachloride extract	100	100	----	100	----	100	----	----	----	----	30
Chemical oxygen demand (O2)	100	500	----	100	----	200	----	----	----	----	----
Hydrogen sulfide (H2S)	----	----	----	----	4	4	----	----	----	----	----
Temperature, F	120	120	100	120	100	120	----	95	----	----	100

Source is "Water Quality Criteria", FWPCA, 1968.

Important parameters of water quality for industrial process use include color; turbidity; pH; temperature; hardness; odor; biochemical oxygen demand; and concentrations of dissolved solids, dissolved oxygen, oil, iron, and manganese. The importance of each of these parameters depends on the intended use. Color and odor for example, are undesirable in water used in the food and beverage industries but are of little significance in water used by the steel industry. Temperature and pH, on the other hand, are important considerations for almost any industrial use.

For most industrial applications, it would be desirable to obtain water containing no dissolved oxygen to limit corrosion in process equipment and piping. Since most other water uses require a high concentration of dissolved oxygen and the higher concentrations indicate relatively less pollution, the planned suppression of dissolved oxygen would not be a realistic objective. The biochemical oxygen demand is a general index of the degree of organic pollution and is of direct concern only in industries such as the food and beverage. For other industrial uses, it serves only as a measure of gross pollution and an indication of the presence of potential specific pollutants or nuisances.

Corrosion, erosion, scale formation, sludge accumulation, and the growth of slime forming microorganisms are phenomena that are particularly detrimental in industrial cooling water systems. Criteria for industrial cooling water depend on quality parameters related to these effects and include pH; turbidity; hardness; and the concentrations of dissolved solids, dissolved oxygen, iron, manganese, chlorides, and sulfates. Temperature is important since the capacity of the cooling system is directly related to the initial temperature of the cooling water. The criteria vary in importance with such factors as materials of construction and the degree of recirculation in a given system.

The quality requirements for boiler feedwater depend on the operating pressure of the boiler; higher pressures impose more stringent quality requirements. The presence of many substances renders feedwater more difficult and expensive to treat. The relative importance of various substances and the effects of boiler operating pressures are indicated in Table 2.

In water to be used for irrigation, the concentrations of dissolved salts and the bacterial quality are of primary importance. The deleterious effects of salts on plant growth can result from osmotic effects, or prevention of water uptake; chemical effects of plant metabolism; or indirect effects on the soil. The presence of coliform bacteria indicates the possibility of food crop contamination. Typical quality criteria for irrigation water are given in Table 3. Unlike water for municipal and industrial use, water for irrigation cannot reasonably be treated for use if the supply is of unsatisfactory quality; the effect of pollution can be elimination of the use. Farmstead water quality criteria are listed in Table 4.

Suspended solids may deposit in streams to block navigation channels or in reservoirs to reduce storage capacity. They can also cause erosion in turbines used for hydroelectric power generation. Dissolved substances, particularly acidic compounds can cause or accelerate corrosion of watercraft and dock facilities. Treatment for such uses, of course, is impractical, but these uses are seldom eliminated by water quality effects. Pollution here is measured by the costs added as a result of maintenance dredging, corrosion damage, and reservoir depletion.

Recreational uses of surface streams, such as swimming, fishing, boating, water sports, and streamside camping; use for commercial fishing; and use for esthetic enjoyment are dependent on suitable water quality. The users can neither alter the quality of the water nor eliminate the effects of pollution. Unsatisfactory quality results in elimination of these uses. Some general indications of the quality criteria associated with these uses may be seen in Table 5. The values given for the parameters would permit general recreational uses of a stream but would not be optimal for fish propagation.

Polluting substances can be assimilated to some extent within a stream, depending on its temperature, dissolved oxygen concentration, flow rate, and other factors. The use of assimilative capacity of a stream must assure that the resultant quality does not impair other beneficial uses. This, of course, is the crux of the water pollution problem, and the quality requirements for assimilative use cannot be stated simply.

TABLE 3

SUGGESTED GUIDELINES FOR SALINITY IN IRRIGATION WATER

Crop Response	TDS mg/l	EC[1] mmhos/cm
Water for which no detrimental effects will usually be noticed	<500	<0.75
Water which can have detrimental effects on sensitive crops	500-1,000	0.75-1.50
Water that may have adverse effects on many crops and requiring careful management practices	1,000-2,000	1.50-3.00
Water that can be used for salt-tolerant plants on permeable soils with careful management practices	2,000-5,000	3.00-7.50

[1] Electrical conductivity

Source is "Water Quality Criteria", FWPCA, 1968.

TABLE 4

KEY WATER QUALITY CRITERIA
FOR FARMSTEAD USES

Characteristic	Recommendations (at point of Use) General Farmstead Uses
Taste and odor	Substantially free
Color	do
pH	6.0 to 8.5
Total dissolved inorganic solids	500 mg/l (under certain circumstances, higher levels are acceptable).
Dissolved organic compounds	No recommendations for total organics. The concentration of persistent chlorinated organic pesticides should not exceed the following: Compound µg/l Endrin.................. 1 Aldrin.................. 17 Dieldrin................ 17 Lindane................. 56 Toxaphene............... 5 Heptachlor.............. 18 H. epoxide.............. 18 DDT..................... 42 Chlordane............... 3 Methoxychlor............ 35
Turbidity	Substantially free
Hazardous trace elements	Levels in excess of those shown are grounds for rejection of a supply: Substances mg/l Arsenic................ 0.05 Barium................. 1.00 Cadmium................ 0.01 Chromium............... 0.05 Cyanides............... 0.2 Lead................... 0.05 Selenium............... 0.01 Silver................. 0.05
Other trace elements	Levels shown below should not be exceeded if alternate sources are available: Substances mg/l Manganese.............. 0.05 Iron................... 0.3 Copper................. 1.0 Zinc................... 5.0 Fluoride............... 0.7-1.2 Nitrate... ....45.0
Radionuclides	pc/l Strontium-90............. 10 Radium-226............... 3 In absence of above radionuclides, 1,000 pc/l gross β activity.
Nonpathogenic microorganisms	To conform to USPHS drinking water standards.

Source is "Water Quality Criteria", FWPCA, 1968.

TABLE 5

WATER QUALITY CRITERIA FOR RECREATIONAL USES

Parameter	Criterion
Coliform organisms per 100 ml	100
Biochemical oxygen demand, ppm	10
Dissolved oxygen, ppm, maximum	2
Oil, ppm	2
pH	6.5-8.6
Turbidity, ppm	20
Color, ppm as Pt	30
Temperature, F	65

Source is "Water Quality Criteria", by McKee and Wolf, 1963.

SURVEILLANCE PROGRAMS

The effective conduct of a national pollution control program requires that reliable information on water quality be collected, analyzed, and evaluated in a timely and efficient manner. This need has become more pressing with the establishment of the Water Quality Standards and plans for their implementation and enforcement, and the resulting increased rate of waste treatment facility construction. The water quality surveillance program must be expanded to determine: (1) the extent of compliance and non-compliance with the Water Quality Standards; (2) the degree to which water quality is improved as a result of pollution abatement measures, such as municipal or industrial waste treatment facility installation; and (3) potential water quality problems requiring corrective action before a crisis situation develops.

Water quality monitoring is required routinely at a sufficient number of locations where effects of pollution on the various legitimate water uses can be detected and evaluated. Such a monitoring network is also necessary for the evaluation of the effectiveness of the local, State, and Federal pollution control programs. The construction of treatment facilities or the completion of basin management plans cannot assure water quality improvements; the effectiveness of control programs can only be determined through long-term monitoring of actual water quality.

General Considerations

For any surveillance program, there are some basic considerations which are, in effect, constraints upon its nature and magnitude. These include: (1) needs of data users (quantity, quality, locations, chronology); (2) available resources (funds, manpower, inherited facilities); (3) legal requirements (Federal, state, local); (4) available technology (equipment, techniques); (5) operational criteria (economic, social, legal, cost-effectiveness); (6) operational responsibility.

In any particular program one or another of these general considerations will be the primary constraint; generally the available resources, particularly available funds, will be the primary constraint. In a program design, the above considerations must be ranked according to relative importance as a guide in selecting various alternatives.

FWPCA Mission

The Federal Water Pollution Control Act, as amended (33 U.S.G. 466 et. seq.), defines the responsibilities of the Federal Water Pollution Control Administration in improving and maintaining the quality of the Nation's waters. Accurate and timely water quality data are needed in order that these responsibilities may be implemented. Such data are particularly needed to carry out the provisions of the following portions of the Act: (1) Section 3(a), which authorizes investigations of the condition of water and identification of discharges which may adversely affect such waters for the purpose of developing comprehensive pollution control programs; Section 5(c), which requires the Secretary of the Interior to collect and disseminate basic water quality data; and Section 10, which pertains to the enforcement of interstate water quality standards. Without water quality data, it is apparent that these provisions could not be carried out.

The effort of the FWPCA in the past was directed toward the collection of limited water quality information at approximately 400 points over long-term periods and 20,000 points over short-term periods and was primarily intended to fulfill Sections 3(a), 5(c), and 10 of the Act. The amendments to Section 10 under the Water Quality Act of 1965 require that the effort be expanded in scope and intensity. If the water quality standards for interstate and coastal waters developed according to the Water Quality Act of 1965 are to be properly enforced, these waters must be monitored to promptly detect violations; determinations must be made for a variety of constituents, sufficiently often, and at a sufficient number of locations. If the Department of the Interior does not participate fully in such a monitoring effort, its assigned duties in administering the standards developed under Section 10 of the Act cannot be adequately accomplished.

SECTION 3

DATA ACQUISITION FOR SURVEILLANCE PROGRAMS DESIGN

The monitoring networks which are in use today for surveillance programs for the most part have grown like topsy, rather than having been designed and planned beforehand. No criticism is intended of the pioneer networks, since they have lead the way for others to follow. When networks of nationwide scope with complex missions are to be designed, a systematized, comprehensive plan should be followed.

DATA SOURCES

In order to have a satisfactory systems plan, it is necessary that adequate data sources be used to implement it. Initial efforts in this study were devoted to obtaining from the Federal Water Pollution Control Administration (FWPCA) and other Federal, state, and private sources, the type of data, which the combined experience of the project team judged necessary for such a program.

Governmental Agency Documents

The documents of prime importance in this study included the following:

Approved Interstate Water Quality Standards and plans for the implementation and enforcement within the study area.

Comprehensive River Basin Surveys published by the Corps of Engineers with the cooperation and assistance of numerous governmental agencies.

Proceedings of conferences on interstate water pollution conducted by FWPCA and the U. S. Public Health Service.

Water Quality Records published by the Geological Survey and the various States.

Quantity of Water Records published by the Geological Survey and the various States.

Publications concerning water quality by the various State Departments of Health or their analogs.

Pollution Surveys published by FWPCA Regional Basin Offices.

Studies of the Federal Power Commission.

Publications of the Ohio River Valley Water Sanitation Commission.

Publications of the Tennessee Valley Authority.

Wastewater Treatment facility surveys by FWPCA.

Water Treatment facility surveys by HEW.

Technical Literature

A review was made of the technical literature concerning water quality and, in particular, surveillance programs. This literature dates from shortly after the end of World War II, however, most of the pertinent articles considered have been authored within the last ten years. Most of the authors hold positions with State or Federal agencies.

On-site Inspection of the River Basins

Throughout the project, there were discussions with personnel of the FWPCA headquarters office in Arlington, Virginia and with personnel of the three regional basin offices. These were Atlanta, Georgia, for the Southeastern Basin; Kansas City, for the Lower Missouri River Basin; and Cincinnati, Ohio, for the Ohio River Basin. For the purposes of this project, the Tennessee River Basin was considered as a portion of the Ohio River Basin, since it drains in that direction. Administratively, however, the Tennessee River Basin is covered by the Atlanta, Georgia office. In addition to the discussion with FWPCA personnel, additional visits and discussions were held with personnel of the Tennessee Valley Authority (TVA) and the Ohio River Valley Water Sanitation Commission (ORSANCO). Additional communications by telephone and letter were accomplished with the particular water pollution control officials in the some 21 states which were covered in some fashion by this project.

Original plans for visiting the river basins were conceived around the idea of visiting the proposed monitoring sites once tentative selections had been made based upon the reading of the collected literature. This approach was abandoned in favor of viewing the sites from the air. This type of aerial surveillance presents a much greater perspective in evaluating the entire basin than trying to compare individual point sites that have been visited. The only other method which even approaches the efficiency of the aerial surveillance technique would be the use of boats to traverse the entire watershed. Certain areas of the streams under consideration in this project are not navigable. Even if all of the streams were navigable, the slow speed of the boat would be unsatisfactory. After consideration of several possible types of aircraft for use in such a survey, it was decided to utilize a four-passenger Cessna 182. This or similar models would be adequate for this purpose. The aircraft is slow enough to allow adequate time for viewing various portions of the stream and yet fast enough to cover a suitable portion of the basin in a day's time. This plane is also slow enough to allow good photography. Two of the seats were removed to provide more room for the necessary gear and maps which were used.

During the flight, tape recorders were utilized to record current impressions, as well as to identify the conditions under which the photographs were taken. A 35 millimeter single lens reflex camera with a through-the-lens light meter was used. This type of metering is very beneficial, since lighting conditions are constantly changing. All of the photographs were taken with the aircraft window open in order to prevent distortion, color changes, and reflections. The chief utility of the photographs is to allow future comparison of various sections within a stream as well as comparison between streams. Photographs of this type could be used for enforcement purposes, provided a sufficient area were depicted to allow positive identification of a particular outfall. For the purposes of this study, however, the photographs were used to improve recall of the various sections of the streams. Possible water quality monitoring sites were photographed. Previous to each day's flight, various maps were assembled. Among the types of maps which were navigation charts as prepared by the Army Corps of Engineers and the 7-1/2 minute, 15 minute and 1:250,000 scale maps prepared by the U. S. Geological Survey. These maps were all of a different scale and coverage was not uniform or universal so that many maps were often necessary in order to maintain coverage. Previous to each flight the maps were coordinated in the manner in which the flight was planned so that the map could be observed and used to locate points of interest within each of the river basins. Since many of the basins are close or overlap, it required that these maps be reassembled for nearly each daily flight. Among the types of things marked were existing water quality monitoring stations, dams, bridges, major intakes or outfalls, and the like. The pre-planning of each of the flights on the ground allowed for the most effective use of time in the air. Weather conditions and the like, as well as logistical problems, controlled the length of each of the flights, but by proper pre-planning of the flight, the time in the air was utilized as effectively as possible. Logistical problems involved the transit from one river to another while attempting to reduce the amount of time spent moving from one watershed to another. On occasion these transfers were made at dusk, or during weather conditions which were unsuitable for surveillance. Each area within a basin was observed only once, unless it was a junction point of two of the rivers. Opinions are therefore usually based upon a single visit.

By comparing the notes made on the showing where various photographs had been taken, the actual photographs, and the notes which were recorded during the flight, almost complete recall of each of the flights over a river basin was possible. Comparisons both within and between river basins were made on this basis. This type of surveillance flight not only provided a portion of the final assessment as to where the surveillance stations would be located, but also provided additional input to the indexing guide which would be further utilized in the Systems Analysis Framework.

The use of a fixed wing aircraft of the type utilized during this project would allow a regional water pollution surveillance officer to inspect his watershed, not only rapidly, but would allow him to become familiar with it in quite a different perspective than is possible from maps, reports, surface visits, and the like. Viewing an entire basin from the air allows a perspective to be obtained which is rather unique. The impact of an individual point source of pollution can then be considered as an effect on the entire basin and associated with the dynamics of the entire basin, rather than as an effect at only a particular point.

DATA HANDLING AND RETRIEVAL

The chief purpose in examining the various documents described was to enable the project team to supplement experience-based thoughts on the data necessary to design a water quality surveillance system and to identify the necessary input material to a Systems Analysis Approach. It was desired to identify the individual factors which should be considered, as well as to locate for future use the relevant data associated with each of the parameters under consideration. The next task was to devise a data handling and retrieval system which would be best for the study purposes. After careful review of many of the data handling systems which are currently in use, it was decided to use an optical coincidence system based on the use of keywords.

Indexing and Retrieval of Published Data

In order to provide the proper input to the system, an "indexing guide" was developed. The indexing guide is exhibited in its entirety at the end of this section. This indexing guide was used by the readers in examining each of the pertinent documents already described. The indexing guide was divided numerically into the following 17 sections:

1. Ohio River Basin
2. Lower Missouri River Basin
3. Southeastern River Basin
4. Water Uses
5. Water Quality Monitoring
6. Data Acquisition and Transmission
7. Data Handling and Dissemination
8. Water Quality Biological Parameters
9. Water Quality Chemical Parameters
10. Water Quality Related Physical Measurements
11. Water Quality Standards
12. Surveillance - Enforcement Agency
13. Pollution Sources
14. Pollution Abatement Methods
15. General
16. Economic Data
17. States

Each of the sections, with the exception of the first three, contained space for additional keywords. The initial group of keywords was designed by the authors. The selected keywords included those which were added by the document readers after review by the authors. This technique was used in order to identify any parameters which had not been included in the original keyword list.

As a document was read, appropriate keywords were chosen and the corresponding page numbers within the document were marked on a space on the indexing guide opposite the keyword. The indexing guide can thus be used as the basis of a retrieval system.

Each keyword corresponds to a plastic indexing card in the information retrieval system. The accession number of each document containing a particular keyword is indicated on that card by the position of a small precision-drilled hole, located by means of an x-y plotter. The position of the hole, and thus the accession number can be re-identified on a light box reader, which also includes an x-y plotter.

By utilizing individual plastic information retrieval cards, one can identify all of these documents in which a particular keyword is significant. By stacking several keyword cards on the lighted reader, one can sequentially obtain only those documents which include the series of keywords corresponding to the cards placed on the reader. Thus, the search can be very broad or very narrow and is completely under the control of the individual. The system was selected because of its ease of use, its compactness, its ability to be used by almost everyone, and the lack of need of expensive data processing equipment. See Figure No. 5.

STORET Inquiries

Throughout the project, the STORET system was utilized on several occasions. The STORET system has been described elsewhere in much greater detail and will not be elaborated on here. In its simplest form, STORET is a computer-operated storage and retrieval system developed over the last several years by various groups within the Department of the Interior. They have developed programs for compiling quite a variety of water resources information into a computer program which has the ability to perform statistical summations of the data, as well as to retrieve the raw data intact, if so desired. The STORET computer system has its headquarters in Washington, D. C. and has several data input-output consoles around the nation.

This FWPCA system assembles and identifies data according to a River Mile Index, which is constructed on the basis of the stream configuration of the watersheds from the headwaters to the ocean. It also identifies data by latitude, longitude, and political boundaries.

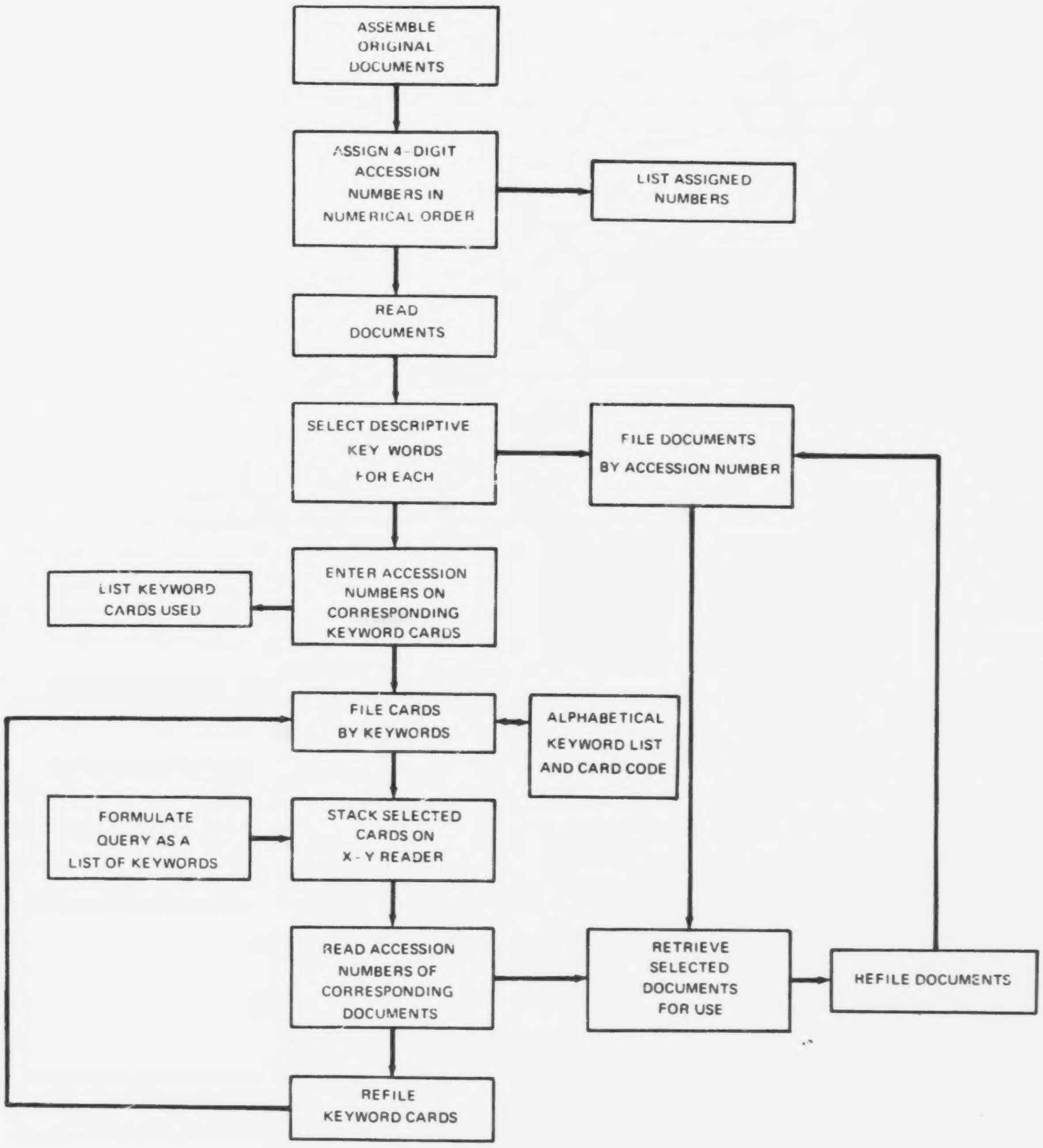

ASSEMBLE ORIGINAL DOCUMENTS
ASSIGN 4-DIGIT ACCESSION NUMBERS IN NUMERICAL ORDER
LIST ASSIGNED NUMBERS
READ DOCUMENTS
SELECT DESCRIPTIVE KEY WORDS FOR EACH
FILE DOCUMENTS BY ACCESSION NUMBER
LIST KEYWORD CARDS USED
ENTER ACCESSION NUMBERS ON CORRESPONDING KEYWORD CARDS
FILE CARDS BY KEYWORDS
ALPHABETICAL KEYWORD LIST AND CARD CODE
FORMULATE QUERY AS A LIST OF KEYWORDS
STACK SELECTED CARDS ON X-Y READER
READ ACCESSION NUMBERS OF CORRESPONDING DOCUMENTS
RETRIEVE SELECTED DOCUMENTS FOR USE
REFILE DOCUMENTS
REFILE KEYWORD CARDS

FIGURE 5

OPERATION OF INFORMATION RETRIEVAL SYSTEM

Inquiries were made to STORET first to identify existing water quality sampling stations on the rivers under study in this project. Later inquiries were expanded to include certain of the water quality data collected in terms of various parameters, and to provide information as to the frequency of collection. These interrogations pointed up many of the good and bad features of the STORET system. In essence, the system is very satisfactory, if all of the data for an entire basin submitted by one agency is wanted. Interrogations covering multi-agencies are more difficult. Not all agencies code their information in the same fashion. For instance, the Geological Survey codes location information by longitude and latitude, whereas the FWPCA identifies location by a river mile index. There are obvious advantages and disadvantages of both systems. However, the use of both systems simultaneously causes great confusion and ineffectiveness. Many of the old water quality network stations are listed by synthetic identifications as to basin, stream index, and river mile index, which also generates confusion.

It appears that certain sub-routines should be developed. For instance, for certain purposes, it may be very useful to have all of the data for a Class II stream and perhaps the first station or so for all Class III streams which intersect and are tributaries to the Class II stream. This type of interrogation is not now possible without obtaining all of the data for the Class III, IV, V, etc., streams listed in the basin. STORET also does not have the capacity to handle large volumes of continuous data effectively. This type of data is being generated throughout the country today and will continue to be generated in a much greater volume in the future. The STORET system is very good, but like many other systems, it needs continual upgrading in order to be effective.

Site Inspection Data Handling and Retrieval

During the on-site inspections of the river basins, certain data were collected utilizing photographs, maps, and dictating equipment. After returning from the flight, this information, along with all of the various discussions and communications with personnel in the regions, was assembled for the individual reaches of each river.

Portions of this summarized material were utilized in (1) extending and improving the indexing guide; (2) describing the overall conditions in the river basin; (3) providing input toward the selection of water quality monitoring sites.

Indexing Guide

An Indexing Guide was developed and expanded on several times during the project. The original model was designed at the start of the project. It was expanded during the literature search and after the visits to the three basins. This Indexing Guide then served not only as a portion of the information retrieval system, but it was input material for the systems analysis framework. The current edition of the Indexing Guide is listed on pages 36 through 41.

INDEXING GUIDE

Surveillance Project
FWPCA - 7098

Accession No. ____________
Indexed by ____________
Date ____________

Title ____

Author ____

		Page Nos.
1.00	Ohio River Basin	
1.01	Main Stem	
1.02	Allegheny River Basin	
1.021	Kiskiminetas River	
1.03	Monongahela River Basin	
1.031	Youghiogheny River	
1.032	Cheat River	
1.033	Tygart River	
1.034	West Fork River	
1.04	Kanawha River	
1.05	Wabash River	
1.06	Tennessee River	
2.00	Lower Missouri River Basin	
2.01	Main Stem	
2.02	Niobrara River	
2.03	Platte River	
2.04	South Platte River	
2.05	North Platte River	
2.06	Kansas River	
2.061	Smokey Hill River	
2.062	Republican River	
2.07	Osage River	
2.071	Marais des Cygnes River	
2.072	Little Osage River	
3.00	Southeastern River Basins	
3.01	Ochlockonee River	
3.011	Apalachee Bay	
3.02	Apalachicola River	
3.021	Flint River	
3.022	Spring Creek	
3.023	Chattahoochee River	
3.024	Apalachicola Bay	
3.03	Choctawhatchee River	
3.031	Choctawhatchee Bay	

		Page Nos.
3.04	Yellow River	
3.041	Pensacola Bay	
3.042	East Bay	
3.05	Escambia River	
3.051	Escambia Bay	
3.06	Mobile River	
3.061	Alabama River	
3.062	Tombigbee River	
3.063	Black Warrior River	
3.064	Mobile Bay	
3.07	Pascagoula River	
3.071	Mississippi Sound	
3.08	Pearl River	
4.00	Water Uses	
4.01	Agriculture	
4.02	Body Contact Sports	
4.03	Commercial Fishing	
4.04	Commercial Navigation	
4.05	Esthetic	
4.06	Industrial Water Supply	
4.061	Process Water	
4.062	Cooling Water	
4.07	Pleasure Boating	
4.08	Potable Water Supply	
4.09	Sport Fishing	
4.10	Shell Fishing - Commercial	
4.11	Hunting	
4.12	Hydro-Electric	
4.13	Mining	
4.14	Recreation	
4.15	Waste Dilution - Transport	
4.16	Wildlife	
4.17	Fish Propogation	
4.18	Irrigation	

		Page Nos.
4.181	Irrigation by Surface Water	____
4.182	Irrigation by Ground Water	____
4.19	Log Transport	____
4.20	Others ____________	____
4.21	Others ____________	____
5.00	Water Quality Monitoring	____
5.01	Analyses, Automatic	____
5.02	Analyses, Field	____
5.03	Analyses, Laboratory Local	____
5.04	Analyses, Laboratory Regional	____
5.05	Sampling, Automatic	____
5.06	Sampling, Composite	____
5.07	Sampling, Manual	____
5.08	Sample Shipping	____
5.09	Photography, Color	____
5.10	Photography, Infrared	____
5.11	Using Aircraft	____
5.12	Using Space Vehicles	____
5.13	Using Watercraft	____
5.14	Gaging Stations	____
5.15	Others ____________	____
5.16	Others ____________	____
6.00	Data Acquisition and Transmission	____
6.01	Telemetry, Leased Line	____
6.011	Telemetry, Radio Link	____
6.012	Telemetry, Telephone Link	____
6.02	Delivery by Mail	____
6.021	Delivery by Express	____
6.022	Delivery by Plane	____
6.03	Display by Hand Typing	____
6.031	Display by Analog Chart	____
6.032	Display by Paper Punch Tape	____
6.033	Display by Magnetic Tape	____
6.034	Display by Visual Display	____
6.035	Display by Machine Typing	____
6.04	Others ____________	____
6.05	Others ____________	____
7.00	Data Handling and Dissemination	____
7.01	STORET Compatibility	____
7.02	Data Format	____
7.03	Manual Handling	____
7.04	Automatic Handling	____
7.05	Regional Storage	____
7.06	National Storage	____
7.07	Regional Dissemination	____
7.08	National Dissemination	____
7.09	Others ____________	____
7.10	Others ____________	____
8.00	Water Quality Biological Parameters	____
8.01	Amphibia	____
8.02	Aquatic Birds	____
8.03	Aquatic Insects	____
8.04	Aquatic Mammals	____
8.05	Aquatic Plants	____
8.06	Aquatic Reptiles	____
8.07	Aquatic Worms	____
8.08	Bacteria	____
8.081	Coliform Bacteria	____
8.082	Fecal Coliform	____
8.083	Fecal Streptococcus	____
8.084	Total Bacteria	____
8.09	Benthic Organisms	____
8.10	Crustacea	____
8.11	Fish	____
8.12	Mollusks	____
8.13	Plankton	____
8.131	Algae - Blue-Green	____
8.132	Algae - Green	____
8.133	Cladocera	____
8.134	Copepods	____

		Page Nos.
8.135	Diatoms	
8.136	Flagellates	
8.137	Rotifers	
8.138	Plankton Algae-Red	
8.14	Bioassay	
8.15	Sphaerotilus	
8.16	Aquatic Fungus	
8.17	Actinomyces	
8.18	Others ____________	
8.19	Others ____________	
9.00	Water Quality Chemical Parameters	
9.01	Acidity	
9.02	Alkalinity	
9.03	Arsenic	
9.04	Barium	
9.05	Biochemical Oxygen Demand	
9.06	Cadmium	
9.07	Calcium	
9.08	Carbon Dioxide	
9.09	Chemical Oxygen Demand	
9.10	Chloride	
9.11	Chromium	
9.12	Copper	
9.13	Cyanide	
9.14	Detergents (Surfactants-MBAS)	
9.15	Dissolved Oxygen	
9.16	Hardness	
9.17	Herbicides	
9.18	Iron	
9.19	Lead	
9.20	Magnesium	
9.21	Manganese	
9.22	Nickel	
9.23	Nitrogen, Ammonia	
9.24	Nitrogen, Nitrate	
9.25	Nitrogen, Nitrite	
9.26	Nitrogen, Organic	
9.27	Nitrogen, Total Kjeldahl	
9.28	Odor	
9.29	Oil and Grease	
9.30	Organics	
9.301	Alcohol (CAE)	
9.302	Chloroform (CCE)	
9.31	Pesticides	

		Page Nos.
9.32	pH	
9.33	Phenol	
9.34	Phosphate	
9.35	Radioactivity	
9.351	Radioactivity - alpha	
9.352	Radioactivity - beta	
9.353	Radioactivity - gamma	
9.36	Selenium	
9.37	Silver	
9.38	Solids	
9.381	Solids, Dissolved	
9.382	Solids, Settleable	
9.383	Solids, Suspended	
9.384	Solids, Total	
9.385	Solids, Volatile Suspended	
9.39	Sodium	
9.40	Strontium	
9.41	Sulfur	
9.411	Sulfur, Sulfate	
9.412	Sulfur, Sulfide	
9.413	Sulfur, Sulfite	
9.42	Taste	
9.43	Tin	
9.44	Zinc	
9.45	Antimony	
9.46	Beryllium	
9.47	Bismuth	
9.48	Boron	
9.49	Chlorine Demand	
9.50	Cobalt	
9.51	Fluoride	
9.52	Molybdenum	
9.53	Potassium	
9.54	Silica	
9.55	Solids, Floating	
9.56	Toxic Substances	
9.57	Vanadium	
9.58	Aluminum	
9.59	Others ____________	
9.60	Others ____________	
10.00	Water Quality Related Physical Measurements	
10.01	Climate	
10.02	Cloud Cover	
10.03	Color	
10.04	Current	

		Page Nos.
10.05	Evaporation	____
10.06	Flow	____
10.07	Humidity	____
10.08	Meteorological	____
10.09	Rainfall	____
10.10	Salinity	____
10.11	Saturation-Percent	____
10.12	Sediment	____
10.13	Snowfall	____
10.14	Temperature, Air	____
10.15	Temperature, Water	____
10.16	Tide	____
10.17	Turbidity	____
10.18	Wind Direction	____
10.181	Wind Speed	____
10.19	Appearance	____
10.20	Discharges	____
10.21	Drainage Area	____
10.22	Gas Bubbles	____
10.23	Hydrographs	____
10.24	Solar Radiation	____
10.25	Specific Conductivity	____
10.26	Others ____________	____
10.27	Others ____________	____
11.00	Water Quality Standards and Enforcement	
11.01	Compact	____
11.02	Hearing	____
11.03	Interstate - Approved	____
11.031	Interstate - Tentative	____
11.04	Intrastate	____
11.05	Local	____
11.06	Orders and Permits	____
11.07	PHS Drinking Water Standards	____
11.08	Enforcement	____
11.09	Abatement Schedule	____
11.10	Others ____________	____
11.11	Others ____________	____
12.00	Surveillance/ Enforcement Agency	
12.01	Atomic Energy Commission (AEC)	____

		Page Nos.
12.02	Bureau of Commercial Fisheries (BCF)	____
12.03	Bureau of Reclamation (BR)	____
12.04	Bureau of Sport Fisheries & Wildlife (SFW)	____
12.05	Conservation	____
12.06	Compact	____
12.07	Corps of Engineers (CE)	____
12.08	Department of Agriculture	____
12.09	ESSA (Weather-Coast-Geodetic)	____
12.10	FWPCA (WPC)	____
12.11	Forest Service (FS)	____
12.12	Geological Survey (GS)	____
12.13	Industrial	____
12.14	Interstate	____
12.15	International Boundry & Water Commission (IBW)	____
12.16	Local	____
12.17	Marine Corps (MC)	____
12.18	Naval Facilities (NFE)	____
12.19	Private	____
12.20	Public Health Service (PHS)	____
12.21	Regional	____
12.22	State	____
12.23	Tennessee Valley Authority (TVA)	____
12.24	Watershed	____
12.25	Commerce, Department	____
12.26	Federal Power Commission	____
12.27	Water Treatment Plant	____
12.28	Ohio River Valley Water Sanitation Commission (ORSANCO)	____
12.29	Missouri Basin Inter-Agency Committee (MBIAC)	____
12.30	Health, Education and Welfare (HEW)	____

		Page Nos.
12.31	Department of Interior	____
12.32	Others ____________	____
12.33	Others ____________	____
13.00	Pollution Sources	
13.01	Acid Mine Drainage	____
13.02	Agriculture	____
13.021	Irrigation Canal Discharges	____
13.022	Pesticide	____
13.023	Fertilizer	____
13.03	Industrial	____
13.031	Chemical Industries	____
13.032	Food Industries	____
13.033	Metal Finishing Industries	____
13.034	Petroleum Industries	____
13.035	Pulp & Paper Industries	____
13.036	Textile Industries	____
13.037	Mineral Industries	____
13.038	Primary Metal Industries	____
13.04	Municipal	____
13.05	Nuclear	____
13.06	Oil and Gas Wastes	____
13.07	Thermal	____
13.08	Accidental Spills	____
13.09	Boat Discharges	____
13.10	Combined Sewer Discharges	____
13.11	Federal Facilities	____
13.12	Feed Lots	____
13.13	Runoff	____
13.14	Soil Erosion	____
13.15	Solids Wastes	____
13.151	Municipal	____
13.152	Industrial	____
13.16	Vector-Biological	____
13.17	Urban Runoff	____
13.18	Construction Runoff	____
13.19	Others ____________	____
13.20	Others ____________	____
14.00	Pollution Abatement Methods	____
14.01	Impoundment	____
14.02	None	____
14.03	Treatment - Industrial	____
14.031	Treatment - Primary	____
14.032	Treatment - Secondary	____
14.033	Treatment - Tertiary	____
14.04	Treatment - Municipal	____
14.041	Treatment - Primary	____
14.042	Treatment - Secondary	____
14.043	Treatment - Tertiary	____
14.05	Costs of Treatment	____
14.06	Disposal Wells	____
14.07	Pipeline Disposal	____
14.08	Operator Training	____
14.09	Pollution Abatement Needs	____
14.10	Regeneration of Wastes	____
14.11	Septic Tanks and Cesspools	____
14.12	Treatment Recommendations	____
14.13	Water Reuse	____
14.14	Mine Drainage Control and Treatment	____
14.15	Sewer Separation and Treatment	____
14.16	Hydro-geological Methods	____
14.17	Construction Plans and Specifications	____
14.18	Sludge Disposal	____
14.19	Construction Projected	____
14.20	Others ____________	____
14.21	Others ____________	____
15.00	General	
15.01	Controlled Discharge	____
15.02	Cost Data	____
15.03	Dredging	____
15.04	Estuaries	____
15.05	Flood Control Dams	____
15.06	Hydro-Power Dams	____
15.07	Impoundments	____
15.08	Lakes	____
15.09	Navigation Dams	____

		Page Nos.
15.10	Saltwater Intrusion	
15.11	Streams	
15.12	Recreation	
15.13	Reservoir	
15.14	Drought	
15.15	Eutrophication	
15.16	Fish Kills	
15.17	Floods	
15.18	Ground Water	
15.19	Surface Water	
15.20	Water Needs	
15.21	Others ____________	
15.22	Others ____________	

16.00 Economic Data

		Page Nos.
16.01	Population	
16.02	Employment	
16.03	Income/Earnings	
16.04	Industry Composition	
16.041	Agricultural	
16.042	Mineral Production	
16.043	Manufacturing	
16.044	Trade, Finance, Service	
16.05	Esthetic Values	
16.06	Resources	
16.061	Mineral	
16.062	Labor Force	
16.063	Power	
16.064	Water	
16.065	Capital	
16.066	Forests	
16.067	Fish and Wildlife	
16.068	Land	
16.07	Multiplier Effects	
16.08	Economic Needs	
16.09	Transportation	
16.10	Data Reduction Methods	
16.11	Economic Climate	
16.12	Aggregate Growth	
16.13	Cost - Benefit Analysis	
16.14	Damages	
16.15	Fishing	
16.16	Gross National Product	
16.17	Hunting	
16.18	Intangibles	
16.19	Input-Output Analysis	
16.20	Land Use	
16.21	Recreation Economics	
16.22	Storage Benefits	
16.23	Tax Structure	
16.24	Others ____________	
16.25	Others ____________	

17.00 States

		Page Nos.
17.01	Alabama	
17.02	Colorado	
17.03	Florida	
17.04	Georgia	
17.05	Illinois	
17.06	Indiana	
17.07	Iowa	
17.08	Kansas	
17.09	Kentucky	
17.10	Louisiana	
17.11	Maryland	
17.12	Mississippi	
17.13	Missouri	
17.14	Nebraska	
17.15	New York	
17.16	Ohio	
17.17	Pennsylvania	
17.18	South Dakota	
17.19	Tennessee	
17.20	West Virginia	
17.21	Wyoming	

SECTION 4

LEGAL PROBLEMS INVOLVED IN THE ESTABLISHMENT OF A FEDERAL WATER QUALITY SURVEILLANCE SYSTEM

A number of legal problems will be involved in the establishment of a Federal water quality surveillance system for the river basins designated in the study.

Initially, the study treats a basic or threshold question involving the statutory authority for the establishment and implementation of a Federal surveillance system. Since such authority is not explicit, specific amendatory legislation is suggested and a draft of amendment is set out in the Appendix to this section.

Other legal problems considered in this section include (1) the establishment of surveillance stations under the authority of the navigation servitude[1/]; (2) the statutory authority for land acquisition for the surveillance system; (3) the establishment of stations on various classes of Federal land pursuant to Federal statute; (4) the types of interests in lands which should be acquired; (5) the evidentiary problems which will be involved in utilizing data and information developed in the operation of the surveillance system in water pollution abatement and enforcement proceedings; (6) the potential liability of the United States to private individuals for damages caused by the system; and (7) the liability of private individuals for damages to the surveillance stations or equipment.

STATUTORY AUTHORITY FOR THE ESTABLISHMENT OF A FEDERAL WATER QUALITY SURVEILLANCE SYSTEM

The Federal Water Quality Surveillance System would be useful in a number of contexts:

> It is anticipated that a national water quality surveillance program would

---

[1/] Navigation servitude - A property interest held by the United States below the high water mark of all navigable streams. It is an interest in which no private property rights may be acquired.

> include technical guidance in legislative matters and ensure that all data gathering and evaluation is accomplished in a uniform, efficient and economical manner. Potential uses of the information from the Federal Water Pollution Control Administration Water Quality Surveillance Program would include justification of Federal expenditures (past and future) for construction of sewage and other treatment facilities, and for research studies; establishment of water quality trends; determination of compliance and non-compliance with water quality standards; documentation of violations and support of litigation for enforcement; and establishment of an alarm system for water quality deteriorations.

The raw data collected by the system will be used to achieve each of these purposes. In addition, the data presumably will be used for pure research purposes such as the effect of particular pollutants on the ecological structure of aquatic environments.

The necessary authority is twofold in nature. First, the rivers and streams must be of a type over which the United States is empowered to exercise its authority. In order to comply with the requirements of the Commerce Clause of the United States Constitution, those rivers and streams must be either "interstate" or "navigable". See Gibbons v. Ogden, 22 U.S. 1 (1824); 33 U.S.C.A. p. 466g(a) (1969 pocket part).

The judicial definition of "navigability" has not remained a constant, though its general parameters were set out in the late 19th Century. In the Daniel Ball case it was held that streams are "public navigable rivers in law which are navigable in fact. And they are navigable in fact when they are used, or are susceptible of being used, in their ordinary condition, as highways of commerce". The Daniel Ball, 77 U.S. 557, 563 (1870). Thus, a stream is navigable in full if it is navigable in part, United States v. Rio Grande Dam & Irrigation Co., 174 U.S. 690 (1899), and remains navigable even if no longer subject to commercial use. See Arizona v. California, 283 U.S. 423 (1931).

In a later case the definition of navigability was broadened to include the susceptibility of a stream for navigation, thereby increasing the number of streams subject to Federal power. United States v. Appalachian

Power Company, 311 U.S. 377 (1940). Finally, in United States v. Grand River Dam Authority, 363 U.S. 229 (1960), the Supreme Court determined that nonnavigable tributaries of navigable streams may be subject to the commerce power of Congress so long as the mainstream falls within the traditional definitions of navigability and in cases in which Congress chooses to exercise its power over such a nonnavigable tributary.

With respect to the second criterion of Federal authority regarding the "interstate" nature of streams or rivers, the Department of the Interior has published guidelines relating to that subject. These guidelines set out the standards for determining interstate streams for which water quality standards are to be established. They provide that:

> Water quality standards, under Section 10(c) (1) of the Act are to be established for, and made applicable to, interstate waters or portions thereof within the State.
>
> 1. The term "interstate waters", as defined in Section 13(e) of the Act, means all rivers, lakes, and other waters that flow across or form a part of State boundaries, including coastal waters.
>
> 2. Within this definition, waters that flow across or form a part of State boundaries are subject to the provisions of Section 10(c) (1) of the Act.
>
> 3. Waters that flow across or form a part of the international boundary between a State and a foreign country are interstate waters within the meaning of the definition provided in Section 13(e) of the Act and similarly subject to the provisions of Section 10(c) (1) of the Act.
>
> 4. Coastal waters subject to the provisions of Section 10(c) (1) of the Act are the ocean waters along straight coasts, the waters along indented coasts which are subject to the ebb and flow of the tides, and the waters of the Great Lakes.

> 5. As noted above, the definition of "interstate waters" is in terms of water bodies - "rivers", "lakes" and "other waters" - and is not limited to only those portions of these water bodies at the point at which they flow across or form a part of State boundaries. In effect, therefore, water-quality standards are to be established for and made applicable to the entire stretch of the interstate waters within a State.
>
> 6. Tributaries of interstate waters, which are not in themselves interstate waters, are not subject to the requirements of subsection 10(c) (1) of the Act. However, it is important to note that the discharge of any matter into such tributaries which reaches interstate waters and reduces the quality of such interstate waters below the established water-quality standards is subject to abatement under Section 10(c) (5) of the Act.

Notwithstanding the guidelines which have been set by the Supreme Court and the Department of the Interior in determining the Federal power over the streams of the United States, it is unlikely that the establishment of a Federal water quality surveillance system on streams of questionable status would encounter the same resistance as Federal water resource projects. For one thing, unlike many water projects, the necessity for the abatement of water pollution has received almost universal acceptance. Secondly, the establishment of a Federal system would result in alleviating the financial burdens of the states in the area of surveillance activities.

Regardless of the way in which the states would greet such a Federal surveillance system, however, the decisions of the United States Supreme Court have greatly expanded the number of streams over which the Federal power extends. Only on the smallest of streams in a river basin would the exercise of Federal authority be questionable. In those instances, the states should be encouraged either to coordinate their own surveillance activities with those of the United States, or to allow the establishment of Federal survillance stations on necessary sites.

In addition to Constitutional validity, the establishment of a Federal water quality surveillance system must also be supported by adequate statutory authority. Logically, one must look to the Federal Water Pollution Control Act, 70 Stat. 498 (1956), as amended, 33 U.S.C., p. 466 et seq. (1964) for such authority. The Act is a compendium of original and amendatory legislation. The basic Act was passed in 1948, 62 Stat. 1155, and has been modified and strengthened by the Federal Water Pollution Control Act amendments of 1956, 70 Stat. 498 (1956), the amendments of 1961, 75 Stat. 204 (1961), the Water Quality Act of 1965, 79 Stat. 903 (1965), and the Clean Water Restoration Act of 1966, 80 Stat. 1246 (1966). Additional amendments are currently under consideration by Congress. S. 7, 91 Cong. 1st Sess. (1969) and H.R. 4148, 91st Cong. 1st Sess. (1969).

The Act is a product of a necessity and a reality - the necessity to halt the destruction of the Nation's water resources, and the reality of countervailing Federal, State, and industry powers. Like much legislation, its goals tend to outstrip its tools for implementation. Throughout the Act, and particularly noticeable in the enforcement provisions, Federal authority is attenuated considerably and authorized often only as a last resort. Cooperation between Federal and State authorities is encouranged by the Act and required in some instances.2/

2/ This tone of compromise is established in Section 1 of the Act, wherein it is provided that:

> In connection with the exercise of jurisdiction over the waterways of the Nation and in consequence of the benefits resulting to the public health and welfare by the prevention and control of water pollution, it is hereby declared to be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the States in preventing and controlling water pollution, to support and aid technical research relating to the prevention and control of water pollution, and to provide Federal technical services and financial aid to State and interstate agencies and to municipalities in connection with the prevention and control of water pollution.

Taken at face value, this policy statement tends to vest enforcement activities primarily in the States, while affording the Federal government a role generally limited to research and assistance. See also 33 U.S.C. p. 466a (c); 33 U.S.C. p. 466c(a); 33 U.S.C. p. 466c(c); 33 U.S.C. p. 466g(b).

Because of the tangled thicket of compromise and accommodation, it is understandable that the lines of authority between Federal and state governments are not clearly drawn. It is also conceivable that Congress, in the attempt to reconcile the conflicting interests of the various parties, may have overlooked the necessity for a comprehensive surveillance system. Since the authorization for such a system is not explicit, the following discussion will examine the various provisions of the Act from which the authority for the system might be established.

Section 3(a) of the Act provides that the Secretary of the Interior shall:

> ... prepare or develop comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary condition of surface and underground waters.
>
> For the purpose of this section, the Secretary is authorized to make joint investigations with any (Federal, state or interstate) agencies of the condition of any waters in any State or States, and of the discharges of any sewage, industrial waters, or substance which may adversely affect such waters. 33 U.S.C.A. p. 466(a) (1969 pocket part).

The "Comprehensive programs" to be developed as a result of the "joint investigations" would appear to encompass the designated programs and purposes of a water quality surveillance system. Furthermore, it would appear reasonable to conclude that the "joint investigations" authorized by Section 3(a) of the Act would clearly comprehend and authorize the establishment of a water quality surveillance system.

Any doubts to the contrary seem to be resolved by several other provisions of the Act. Section 5(a) for example, provides that the Secretary "shall conduct ... research, investigations, experiments, demonstrations, and studies relating to the causes, control, and prevention of water pollution". 33 U.S.C.A. p. 466c(a) (1969 pocket part). Section 5(b) allows the Secretary of the Interior to conduct investigations, at the request of state or interstate agencies, on specific pollution problems. 33 U.S.C.A. p. 466c(b) (1969 pocket part). And Section 5(c) requires the Secretary, in cooperation with

Federal, state and interstate agencies, to "collect and disseminate basic data on chemical, physical, and biological water quality and other information insofar as such data or other information relate to water pollution and the prevention and control thereof". 33 U.S.C.A. p. 466c(c) (1969 pocket part).

On the basis of these and other provisions of the Act,[3] the conclusion can be drawn that Congress recognized the need for adequate surveillance operations and therefore provided for their implementation. The conclusion is further confirmed by the fact that the Federal government is given a major responsibility for enforcing the water quality standards established under the Act, and without the means for determining violations, such as a surveillance system, enforcement would rest on mere conjecture. See U.S.C.A. p. 466g(a) (1969 pocket part).

Finally, the statutory authority for the establishment of a surveillance system has been recognized by the Office of the President in an Executive Order relating to pollution caused by Federal facilities. Section 3 of Executive Order 11507 of February 4, 1970 (35 Fed.Reg. 2573), provides that:

> (a) Heads of agencies shall, with regard to all facilities under their jurisdiction:
>
> (1) Maintain review and surveillance to ensure that the standards set forth in section 4 of this order are met on a continuing basis.

Clearly, Executive Order 11507 contemplates the establishment of a system to monitor the discharge of pollutants from Federal installations and from facilities ". . . owned by or constructed or manufactured for the purpose of leasing to the Federal Government." Without such a system of surveillance, it would be impossible to assure that pollution control standards ". . . are met on a continuing basis."

---

[3] These provisions include Section 5(e), 33 U.S.C.A. p. 466c(e) (1969 pocket part) which authorizes the Secretary to establish, equip and maintain field laboratory and research facilities; and Section 5(d) (B), 33 U.S.C.A. p. 466c(d) (B) which authorizes the Secretary to develop and demonstrate methods for identifying and measuring the effects of pollutants on water uses.

It is possible that the surveillance apparatus contemplated in Executive Order 11507 is much different than the multipurpose system outlined in the present study. Nevertheless, comprehensive surveillance is necessary for Federal as well as for private activities since many of the problems, such as discharges from waste treatment facilities, are identical.

A comprehensive surveillance system established principally for the monitoring of Federal activities need not be limited exclusively to such a purpose. Indeed, in many instances, it would seem impossible for such a system to monitor only Federal pollutants. Consequently, it appears entirely feasible that the surveillance system established to monitor pollution from Federal sources under Executive Order 11507 could also be used successfully to monitor pollution from all other sources. Since Federal activities and those of Federal contractors and grantees are presently so geographically extensive, it is possible that the surveillance system established to monitor Federal activities would be sufficient to monitor pollution from all sources. In the case it is not, however, the independent statutory authority contained in the Act and discussed supra[4/] appears sufficient to provide the necessary statutory basis for a comprehensive surveillance system.

It is relevant to point out that the independent statutory authority discussed hereinbefore contains a number of references to requirements for cooperation between Federal, state, and interstate agencies in carrying out activities under the Act. For example, the investigations authorized by Section 3(a) of the Act are to be conducted jointly with state and interstate agencies. Sections 5(a), 5(b), and 5(c) of the Act, discussed supra, also contain references to cooperative efforts between Federal, state and interstate agencies.

Finally, inasmuch as the surveillance system will be used principally as an enforcement mechanism, the following provision of the Act is most significant:

> Consistent with the policy declaration of the Act, state and interstate action to abate pollution of interstate or navigable waters shall be encouraged and shall not, except as otherwise provided by or pursuant to court order

---

[4/] Supra - above.

> under sub-section (h), be displaced by Federal enforcement action. 33 U.S.C.A. p. 466g(b) (1969 pocket part).

The language of these sections raises the question whether a comprehensive surveillance system can be established and operated exclusively by the Federal government, or whether the participation of state and interstate agencies is imperative.

The most consistent conclusion would appear to be that the Federal Government is directed to seek the cooperation of state or interstate agencies, but, if it is not forthcoming, may proceed independently.

It is difficult to conclude that Congress intended that states, by lack of funds or mere intransigence[5], could thwart the investigations and programs necessary to fulfilling the purpose of the Act. This conclusion underlies the establishment of the Task Force on Pollution Enforcement which was ordered by Secretary of the Interior Walter J. Hickel in July, 1969. The Task Force, in September, 1969, as a result of evidence gathered by Federal monitoring activities, recommended the convening of hearings and the possible initiation of litigation to halt excessive pollution in certain areas of Kansas, Oklahoma, Ohio and the Lake Erie Basin. Consequently, it appears reasonable to conclude that the Federal Government may establish a surveillance system without the joint participation of state and interstate agencies. Nevertheless, the cooperation and joint participation of state and interstate agencies should be sought to the fullest extent even though the failure of state participation should not be construed to prohibit the establishment of an independent Federal water quality surveillance system. With respect to the participation of interstate agencies in water pollution control activities, it should be noted that there exist at least ten interstate compacts which deal directly with water pollution control problems. Among those, at least two directly affect two of the river basins under consideration in this study. The Ohio River Valley Sanitation Compact (ORSANCO), 54 Stat. 752 (1940) encompasses the states of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Tennessee and West Virginia. The Tennessee

---

[5] Intransigence - The state of being uncompromising or irreconcilable; stubborness.

River Basin Water Pollution Control Compact, 72 Stat. 823 (1958), numbers among its signatories the States of Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia.

Both compacts provide for interstate commissions, and in both cases the commissions are invested with certain regulatory functions, including the establishment of water quality criteria. The Federal government is represented by a delegate on the ORSANCO commission. In neither case is the commission authorized to issue enforcement orders without a majority vote of the compact commissioners.

The jurisdiction of each commission extends only to the waters in the interstate drainage basin with which the particular compact is concerned. However, even this limited jurisdiction enables the commissions, like the Federal government, to establish water quality criteria for the entire breadth of a stream regardless of state boundaries. Were it not for this authority, and that of the Federal government, it is conceivable, indeed likely, that different criteria would obtain on either side of the center of a river which borders two states. Since both compact commission's and the Federal government have authority over such interstate streams, any differences in criteria or standards which might otherwise arise can be resolved. Indeed, the Federal Water Pollution Control Administration already has undertaken to reconcile conflicting criteria submitted by states bordering several of the Great Lakes.

As an example of the duties and authority vested in pollution compact commissions, ORSANCO is authorized:

> to survey the sanitation district established by the compact; study the pollution problems; make a comprehensive report for prevention or reduction of pollution; confer with national and federal authorities; draft and recommend uniform legislation dealing with stream pollution to the signatory states; consult with and advise the states and their subdivisions and other persons in the state regarding pollution problems; and recommend enactments to any state for furtherance of the purposes of the compact. Gindler, Waters and Water Rights 341 (Clark, ed. 1967).

Regarding enforcement of water quality standards adopted by the commission, both ORSANCO and the Tennessee River Basin Commission are authorized to issue administrative enforcement orders and to obtain court orders for compliance in either the state or Federal courts.

Finally, both compacts provide for coordination in their operations. The Tennessee River Basin Compact provides that it is not to conflict with the provisions of ORSANCO, but that the Commission is free to set higher standards for the signatory states than those provided by ORSANCO.

In sum, each compact commission is a viable body which should be consulted in all operations of a Federal water quality surveillance system, and should be invited to participate in those operations to the greatest extent possible.

ACQUISITION OF SITES FOR SURVEILLANCE STATIONS

An initial legal problem concerns the acquisition of sites for the proposed surveillance stations. Depending on the projected size and placement of the stations, different problems will arise, including the necessity for payment of compensation to appurtenant landowners.

Site Acquisition Under the Navigation Servitude

It is likely that certain types of surveillance stations will not require the use of lands which are situated above the high water mark of a river. This is particularly the case in situations where it is advantageous to establish stations on pilings anchored below the high water mark of a river or where it is desirable to transect streams with sampling equipment in order to obtain readings at various points of flow, while anchoring the equipment below the high water mark.

In those instances in which surveillance stations or equipment can be situated below the high water mark on rivers or streams, it is possible that the United States will not incur liability for the payment of compensation to private landowners who are riparian to the streams. In such cases, it may be possible for the United States to exercise authority pursuant to the "navigation servitude" vested in the Federal government.

This servitude, which springs from the Commerce Clause of the United States Constitution, vests dominant control of the stream bed (up to the ordinary high water mark) of navigable waters in the Federal government. See e.g., United States v. Chicago, Milwaukee, St. Paul & Pacific Railroad Co., 312 U.S. 592 (1941). Any lands situated below the high water mark are, thus, held subject to this dominant interest of the United States and may be taken by the Federal government without compensation to the private landowner. United States v. Willow River Power Co., 324 U.S. 499, 509 (1945).

Under the traditional view, this right of the United States to take private lands without compensation appears to be limited to those situations in which the dominant interest is exercised in aid of navigation. See, e.g., United States v. Chicago, Milwaukee, St. Paul & Pacific Railroad Co., supra; United States v. Willow River Power Co., supra; United States v. Chandler-Dunbar Water Power Co., 229 U.S. 53 (1913). However, the courts have also recognized that, as long as the interests of navigation are served, other purposes may also be advanced. See e.g., United States v. Twin City Power Co., 350 U.S. 222 (1956).

Nevertheless, because of this limitation, it is likely that the "traditional view" would reject the right of the United States to exercise the "navigation servitude" in acquiring sites for surveillance stations on the ground that such stations are not an aid to navigation.

In order to reach an opposite conclusion, at least four courses are open: a position based upon the "traditional view" of the servitude; a position based upon a novel view of the servitude; a position based upon an expanded view of the servitude; and, a position based upon an historically updated view of the servitude.

The "Traditional" View

The approach using the "traditional view" of the servitude merely recognized the fact that pollution is a burden on navigation since it increases the corrosion rate of vessels used in navigation, makes navigation more difficult as a result of water-clouding, damages dock facilities and has numerous other deleterious effects on navigation. Since the surveillance stations are a part of a program designed to eliminate pollution, they will in fact, aid navigation and, thus, allow the servitude to be used for the traditional purpose of assisting navigation.

The use of this approach has at least one major advantage and one major disadvantage.

The advantage of a position based upon the traditional view of the servitude is the fact that the courts are not asked to change existing law in any manner. Rather, since the servitude is being used for the traditional purpose, in aid of navigation, the court is merely required to recognize that pollution is a burden upon navigation which surveillance stations will assist in eliminating.

The infirmity of the traditional approach lies in the Federal pollution control laws themselves. The Federal Water Pollution Control Act, 62 Stat. 1155 (1948), as amended, 33 U.S.C. p. 466 (1964), is designed for the elimination of water pollution, and neither the Act nor its legislative history reflect an interest on the part of Congress to assist or advance navigation.

Consequently, opponents of this view might well take the position that, since the statutory authority for the surveillance system is not designed to aid navigation, and the surveillance system itself is not designed to aid navigation, the servitude cannot be exercised in the acquisition of surveillance sites.

The "Novel" View

Under the "novel" view of the servitude, the bed of a navigable stream is viewed as the corpus of a public trust. The United States, as trustee, may use lands situated within the stream bed without compensation to private owners, so long as the use is for purposes of navigation, commerce or fisheries, all of which tend to benefit all of the people of the state. See generally, Colberg, Inc. v. California, 432 P. 2d 3 (Cal. 1967); Crary v. State Highway Commission, 68 So. 2d 468 (Miss. 1953).

The land necessary for the surveillance sites could, under this view, be acquired without compensation to private owners since the land would be used for the elimination of pollution, and thus for the purpose of aiding commerce, navigation and fisheries.

The development of the "common law of the public trust", however, must be considered in a state of infancy, and not sufficiently established to guarantee the validity of such a view of the navigation servitude.

The "Expanded" View

With respect to the third alternative mentioned above, several commentators have argued for an expanded view of the "navigation servitude". See, *e.g.*, Bartke, *The Navigation Servitude and Just Compensation - Struggle for a Doctrine*, 48 Oregon Law Review 1 (1968). These observers reach the conclusion that the "navigation servitude" is proprietary in nature. That is, because of the dominant interest of the United States, land situated within the bed of a navigable stream is viewed, in relation to navigation, as a part of the public domain. Therefore, when dealing with this dominant interest, the authority exercised is that vested under the property clause of the United States Constitution.

Adopting this approach the position could be advanced that since all lands situated within the bed of a navigable stream are a part of the public domain, they are subject to the proprietary interest of the United States, and, consequently, may be utilized without compensation to the private owner.

The difficulty in adopting the expanded view of the navigation servitude lies in the fact that, though the dominant interest of the United States might validly be viewed as a segment of the public domain, the cases from which this view of the servitude is drawn have all dealt with the question of navigation. In essence, therefore, these cases tend to support the view that lands below the high water mark are public lands only when the navigation and authority of Congress is being exercised. In all other instances, and under the exercise of other authority, the lands are not public lands and are subject to the compensation provisions of the Fifth Amendment when taken for a purpose other than navigation.

The "Up-Dated" View

Finally, under the fourth approach, the position can be advanced that the definition and use of the "navigation servitude" has been restricted to navigational purposes because of a view of commerce which is now out-dated.

In this regard, it was early conceded that, by virtue of the Commerce Clause, the United States has exclusive and absolute control over certain waterways. Gibbons v. Ogden, 9 Wheat. 1 (1824). It was also recognized that because of this exclusive and absolute control, the United States had an interest in the beds of navigable waterways (i.e., the "navigation servitude") which was superior to the rights of private owners. United States v. Chandler-Dunbar Water Power Co., 229 U.S. 53, 62 (1913). The servitude exists to serve and make effective the exclusive and absolute control of the United States. This exclusive and absolute control is the power to regulate commerce and, thus, the servitude exists to serve commerce.

However, historically, the servitude has been limited to "purposes in aid of navigation" - a much narrower scope than "purposes in aid of commerce". This limitation is the result of the manner in which the Commerce Power has developed in relation to waterways.

Thus, traditionally, the power of absolute control has been limited to navigable waterways. Gibbons v. Ogden, supra. Such a result appears to have been reached because water has been viewed merely as a conduit of commerce rather than as an article of commerce itself. It was reasoned that since only navigable waters could support commerce, the Commerce Power was limited to navigable waters. It therefore followed naturally to equate commerce with navigation, and the servitude, which derives its character from the absolute power which it serves, was consequently limited to purposes in aid of navigation.

It is the view of the authors, however, that whatever the reasons for viewing water as a mere conduit of commerce previously, this view is no longer justified. Water itself has become an article of commerce rather than a mere "navigation conduit", and should be considered in that light.

When it is so considered, the historical equation of "commerce" with "navigation" is no longer valid. The Commerce Power encompasses not only navigable streams, but also all streams in which water is an article of interstate commerce.

Similarly, the scope of the servitude should not be limited to purposes in aid of navigation. The servitude follows the power which it serves. Since "commerce" and "navigation" can no longer be equated, the servitude cannot remain limited in exercise to purposes in aid of navigation but must follow the Commerce Power. Thus, it should be considered available for use in aid of commerce, and therefore in aid of controlling pollution. The conclusion thereby follows that the navigation servitude may be used to acquire surveillance sites since they will be used in a program designed to eliminate pollution and aid interstate commerce by removing a burden on interstate waters.

Establishment of Surveillance Stations on Federal Land

Assuming that many of the surveillance stations will be positioned beyond the high water mark of the rivers, it will be necessary to secure suitable sites for their operation. Problems and costs of site acquisition may be eased greatly in those instances in which the stations can be established on Federal lands. In such cases it will be necessary to secure the authorization of the agency responsible for the administration of the lands involved. No payment would be necessary. However, any such permission must be authorized by statute and should be in writing and signed by the official responsible for management of the area within which the station would be located. While it is not likely that special permits would be required, it is important that the sites be segregated from other uses by executive withdrawal or by a suitable declaration prohibiting conflicting uses.

Public Lands

It is quite probable that surveillance stations will be needed on public lands owned by the United States. In most instances, barring the existence of previous withdrawals or reservations, the public lands are under the jurisdiction of the Secretary of the Interior and administered and managed by the Director of the Bureau of Land Management. In order to establish a surveillance site on the public lands, it would be necessary for the Secretary to withdraw the site from entry by executive order pursuant to the Pickett Act, 36 Stat. 847 (1910), 43 U.S.C. p. 141 et seq. (1964), or exercise his general authority to withdraw and reserve lands from entry and settlement. See United States v. Midwest Oil Co., 236 U.S. 459 (1915). The authority to withdraw lands under the Pickett Act has been delegated to the Secretary of the Interior pursuant to Executive Order No. 10355, 17 Fed. Reg. 4831 (1952). In this regard, the Act provides that:

> The President may, at any time in his discretion, temporarily withdraw from settlement, location, sale, or entry any of the public lands of the United States, including Alaska, and reserve the same for water-power sites, irrigation, classification of lands, or other public purposes to be specified in the orders of withdrawals, and such withdrawals or reservations shall remain in force until revoked by him or by an Act of Congress. 43 U.S.C. p. 141 (1964).

There is little doubt that the establishment of surveillance stations is a "public purpose" as contemplated by the Act, and would therefore be the subject of a valid withdrawal.

A withdrawal of lands pursuant to the Pickett Act, however, has one potential danger which should not be overlooked. Section 2 of the Act provides that any lands so withdrawn "shall at all times be open to exploration, discovery, occupation and purchase under the mining laws of the United States, so far as the same apply to metalliferous minerals...." 43 U.S.C. p. 142 (1964). Therefore, in order to prevent the location of metalliferous mining claims on the sites occupied by the surveillance stations, a withdrawal pursuant to the general authority of the Secretary would be preferable. See e.g., United States v. Midwest Oil Co., supra.

In order to initiate the withdrawal, the Federal Water Pollution Control Administration would make application to the Bureau of Land Management. Upon application, the lands become segregated and are no longer open to entry.

In addition to making the withdrawal, it would also be advisable for the Secretary to transfer sufficient administrative jurisdiction over the site to enable the Federal Water Pollution Control Administration to perform their duties of monitoring and surveillance. Such a transfer could be accomplished in the withdrawal order, or by separate Secretarial Order.

Naturally, the entire surveillance program assumes that the Federal Water Pollution Control Administration can be a land-administering agency. Nothing in the applicable Statutes appears to prohibit such responsibility. However, it would be advisable to establish the principle through an opinion of the Solicitor of the Department of the Interior or by the Attorney General of the United States.

National Forest Lands

With respect to the establishment of surveillance stations on National Forest lands, which are administered by the Secretary of Agriculture, the authority is less clear. Research has not disclosed any Congressional authorization for an interdepartmental transfer or exchange of such lands. However, the Secretary of Agriculture is authorized:

> to permit ... any public ... agency, to use and occupy suitable areas of land within the national forests not exceeding eighty acres and for periods not exceeding thirty years, for the purpose of constructing or maintaining any buildings, structures, or facilities necessary or desirable for education or for any public use or in connection with any public activity. The authority provided by this section shall be exercised in such a manner as not to preclude the general public from full enjoyment of the natural, scenic, recreational, and other aspects of the national forests. 38 Stat. 1101 (1915), 16 U.S.C. p. 497 (1964).

It seems clear that such authorization embraces other Federal agencies, such as the Federal Water Pollution Control Administration, in addition to state and local agencies. It also appears that the language is broad enough to authorize the establishment of surveillance stations within the national forests upon the approval of the Secretary of Agriculture.

Whether the Secretary of Agriculture can condition the permits so as to preclude the location of mining claims after establishment of the stations is unclear. See 16 U.S.C. p. 482 (1964). However, the Secretary of the Interior is authorized to withdraw the lands from the location of mining claims by virtue of his delegated authority. 43 U.S.C.A. 3141 (1964 ed.); E.O. No. 10355, 17 Fed. Reg. 4831, May 26, 1952. Such withdrawals should be effected immediately upon issuance of the permits.

Bureau of Reclamation Project Sites

It is possible that the Bureau of Reclamation has acquired jurisdiction over certain potential reclamation project sites on portions of the Lower Missouri River Basin. In most instances, the reclamation project sites will have been withdrawn by the Secretary pursuant to his authority under Section 3 of the Reclamation Act of 1902, 32 Stat. 388 (1902), 43 U.S.C. p. 391, p. 416 (1964). If any such sites are to be used for surveillance stations, it would appear advisable to transfer administrative jurisdiction over a portion of the sites to the Federal Water Pollution Control Administration.

Such an intradepartmental transfer of jurisdiction could be accomplished by a modification of the reclamation withdrawal over the lands to be used for the station, followed by a restoration to withdrawn status under the general authority of the Secretary to withdraw public lands. (See discussion, *supra*.) In the alternative, it is possible that agreement might be reached between the Bureau of Reclamation and the Federal Water Pollution Control Administration allowing the use of a portion of the reclamation site for surveillance purposes.

Corps of Engineers Project Sites

If surveillance stations are to be established on lands owned and administered by the Army Corps of Engineers - a distinct possibility in any of the three river basins under consideration - the authority for a transfer of rights to the Federal Water Pollution Control Administration is clear. The Secretary of the Army is authorized:

> to grant leases of lands, including structures or facilities thereon, at water resource development projects for such periods, and upon such terms and for such purposes as he may deem reasonable in the public interest ... *Provided further*, that preference shall

> be given to Federal, State, or local governmental agencies, and licenses, or leases where appropriate, may be granted without monetary considerations, to such agencies for the use of all or any portion of a project area for any public purpose, when the Secretary of the Army determines such action to be in the public interest, and for such periods of time and upon such conditions as he may find advisable....
>
> No use of any area to which this section applies shall be permitted which is inconsistent with the laws for the protection of fish and game of the State in which such area is situated. 58 Stat. 889 (1944) as amended Oct. 23, 1962, 76 Stat. 1195 (1962), and Sept. 3, 1964, 78 Stat. 899 (1964); 16 U.S.C.A. p. 460d (1969 pocket part).

In addition to this authority, the Secretary of the Army is afforded the general power to lease non-excess property within his jurisdiction. 70A Stat. 150 (1956); 10 U.S.C. p. 2667 (1964).

Consequently, few legal difficulties should be anticipated in acquiring surveillance sites on property under the jurisdiction of the Corps of Engineers. The possibility of interdepartmental administrative difficulties exists, and may be more troublesome than the legal questions involved.

Indian Reservations

The lower Missouri River Basin drains several Indian reservations upon which the location of surveillance stations may be desirable. Among them are the Ponca, Santee, Winnebago and Omaha Reservations in Nebraska and the Iowa Reservation on the border between Nebraska and Kansas.6/

6/ For the legal status of the Ponca Tribe see 25 U.S.C.A. pp. 971-980 (1969 pocket part).

All the land excompassed by the reservation is either in tribal ownership or owned by individual Indians. None of the land is owned by the United States in trust for the Indian tribes. Consequently, any rights to the reservation lands must be granted either by the tribe or by the individual owners of the lands.

Land owned in unrestricted, fee simple title by members of the Tribes must be acquired in the same manner as any other privately-owned lands. Allotted lands, at least those over which statutory restrictions are imposed, may be leased according to the terms of the relevant Federal statutes. See Federal Indian Law (1958 ed.), pp. 804-818. The same is true regarding the leasing of tribal property. See Federal Indian Law, supra, pp. 687-710.

General Problems in the Establishment of Surveillance Stations on Federal Lands

In some instances, Federal lands may be devoted by statute to a single purpose which is incompatible with the establishment and operation of surveillance stations. In such cases, legislation may be needed to broaden the purpose for which the sites may be used unless alternative sites are available and equally suitable to surveillance activities. Examples of such single purpose Federal areas would be national parks and monuments and defense or military installations. Of course, in adopting such legislation, Congress would be faced with the question of the compatibility of surveillance stations with the purposes for which the lands were originally set aside.

Without advance knowledge of the potential sites for surveillance stations on Federal lands, it is impossible to predict the individual problems which may arise in each case. However, as a general proposition, it should be noted that mere Federal ownership of potential sites does not guarantee the use of that site for surveillance purposes.

In this regard, many interdepartmental and intradepartmental obstacles may make acquisition of proper sites on Federal lands no more feasible or economical than acquisition of sites on state or private lands. The funds saved by the lack of a need to purchase Federal sites may well be expended in the intragovernmental intricacies of land transfers. Nevertheless, Federal lands frequently offer many advantages over state or private lands, and should be considered carefully in site selection. Indeed, if their technological or scientific merit is equal to alternate sites on state or private lands, the Federal sites would likely be preferable in most instances.

Each of the three river basins under consideration drains Federal lands upon which surveillance stations might be located. The Southeastern River Basins encompass a number of National Forests, including the Apalachicalla and Conecuh National Forests. The Ohio River Basin drains the Allegheny, Wayne, Hoosier and Shawnee National Forests. The Lower Missouri River Basin drains a wider variety of Federal lands, including public lands in Colorado and Wyoming, National Forests in Colorado, Wyoming and Nebraska, and Indian reservations in Nebraska. Moreover, an undetermined number of water project sites may exist in the three basins, some of which no doubt would be under the jurisdiction of the Army Corps of Engineers or the Bureau of Reclamation. It is possible that surveillance stations may be located ultimately on all the types of Federal lands which are appurtenant to the rivers under consideration.

Acquisition of Surveillance Sites from States, Municipalities or Private Owners

In all likelihood it will be necessary to acquire interests in state, local or private lands for the establishment of surveillance stations. The following discussion concerns the legal problems which may arise in connection with the acquisition and use of such lands.

Authority of States and Municipalities to Transfer Interests in Land

With respect to potential sites owned by states or municipalities, an initial problem concerns their authority to transfer legal interests in real property to the United States. Rights which might be acquired include fee simple title, lease, permanent or temporary easement, or license.

Since licenses are generally revocable at will by the licensor, it would be desirable that a more substantial and permanent interest be acquired for the establishment of surveillance stations. Consequently, the real question concerns the authority of states or municipalities to transfer legal interests at least as substantial as a temporary easement.

Without a comprehensive review of all the states and municipalities which own potential surveillance sites in the three river basins under consideration, a definitive answer for each particular situation is impossible. However, as a general rule, states and municipalities possess the authority to grant legal interests in real property which they own.[7]

---

[7] The following state statutes are representative of the authority granted by the states for the acquisition of state or private lands:

Florida - The United States may purchase, acquire, hold, own, occupy and possess such lands within the limits of this state as they shall seek to occupy and hold as sites on which to erect and maintain forts, magazines, arsenals, dockyards, and other needful buildings or any of them, as contemplated and provided in the constitution of the United States; such land to be acquired either by contract with owners, or in the manner hereinafter provided. F.S.A. p. 6.02. See also F.S.A. p. 6.03 and F.S.A. p. 589.10.
Pennsylvania - Specific legislation appears to be necessary, but is by no means unprecedented.
West Virginia - The State of West Virginia authorizes the United States to acquire lands in the State by purchase, lease, condemnation, or otherwise for the purpose *inter alia*, of constructing works of public improvement, or for any other purpose for which the land may be needed by the United States. 1 W.V.C. p. 1-3. See also 20 W.V.C. p. 5A-4.
Tennessee - The State of Tennessee authorizes the United States to acquire, by purchase or otherwise, lands within the state as in the opinion of the Federal government, the State Forester, and the Governor, concurring, may be necessary for, *inter alia*, the improvement and development of the Tennessee River Basin. 11 T.C.A. p. 1001. See also 11 T.C.A. p. 1401, p. 1416 and 12 T.C.A. p. 201.
Colorado - The State of Colorado authorizes the State Board of Land Commissioners to sell any State land in such parcels as they shall deem for the best interest of the State. 112 C.R.S. 3-25. See also, 66 C.R.S. 28-3(5).

As with Federal parklands, cases of potential incompatibility of uses may arise when surveillance sites are sought on state or municipal parklands. Unless accommodations can be made allowing the establishment of the stations in such areas, alternative sites must be chosen.

The acquisition of sites from state or local governments will require consultation with the officials responsible for the management of those areas. In the case of state governments, the state park commission or comparable authority will often be the responsible agency. Other possibilities include the state highway department and the state public utility commission. In all cases involving the acquisition of state-owned sites, the state water pollution control agency should be consulted and advised as to the site selection and acquisition process. The same process should be followed with respect to the governor and the state legislature, at least as to those legislators who represent districts within which the stations are to be placed.

In the case of municipalities, the local city council will, in most instances, be vested with sufficient authority for the granting of appropriate easements or permits. They, too, should be kept fully informed of the site selection process and the nature of the surveillance program.

It is likely that in site acquisition from state or local governments, it will be necessary to make formal presentations to the appropriate agencies and officials regarding the feasibility and necessity of the proposed sites. In any such presentations, legal counsel from the Office of the Solicitor, Department of the Interior should be present or fully consulted in order to effectuate the proper agreements. The agreement should authorize a relatively long term use of the site and provide for suitable access. It is not necessary that it provide for exclusive use if other uses are compatible with the purposes for which the station is established and operated.

The establishment of surveillance stations on privately-owned lands may prove considerably more troublesome than on Federal lands. It involves two problems which are not as acute with the use of Federal lands - payment for use of the lands and the necessity for statutory authority to acquire the lands. Both problems exist in the acquisition of state and municipal lands, and the following discussion is equally applicable to them.

Authority of the United States to Acquire Lands for the Establishment of a Surveillance System

The statutory authority of the Secretary of the Interior or the Federal Water Pollution Control Administration to acquire lands for the location of surveillance stations is, at best, unclear. At least four potential avenues for acquisition of lands exist if the requisite statutory authority is present. These include acceptance of sites by donation, or acquisition of lands by purchase, condemnation or exchange.

Acceptance of Sites by Donation

There is apparently authority for the acceptance of sites by donation under existing law. In a situation involving the acceptance of a site for a proposed water research laboratory in Oklahoma, the Associate Solicitor for Water Resources and Procurement, Department of the Interior, concluded that the Act of July 14, 1960, 74 Stat. 506, (1960); 43 U.S.C. p. 1364 (1964), provided the necessary authority for such acceptance. That Act reads in part that:

> The Secretary of the Interior may accept contributions or donations of...property, real, personal or mixed for the improvement, management, use, and protection of the public lands and their resources under his jurisdiction....

The Associate Solicitor concluded, in a memorandum of November 5, 1968, to the Assistant Commissioner for Administration, Federal Water Pollution Control Administration, that:

> ... the authority of the Secretary to accept donations of land under the cited statute is predicated upon the benefits that will accrue to the public lands as defined in the Act. The authority does not require that the acquisition become a part of the public lands, but only that it will be beneficial in the "improvement, management, use, and protection of the public lands". The conservation and development of water resources is directly related and of vital concern to the public lands and the improvement and management of those lands depends to a high degree upon the appropriate development of the water

> resources serving them. The purpose of the laboratory. ... is to conduct "research, investigations, experiments, field demonstrations and studies and training relating to the prevention and control of water pollution". 33 U.S.C. 466(c)(e). This water conservation purpose has a direct relation to the development and use of the public lands and, accordingly, it is within the jurisdiction of the Secretary pursuant to the cited statute to accept the donation of land. ...

Clearly, then, the Secretary may accept donations of land to be used for the construction of facilities having a general impact upon the "improvement, management, use, and protection of the public lands and their resources under his jurisdiction...." The laboratory in Oklahoma was such a facility.

While there is no specific ruling on the question, it would appear that water quality surveillance stations established in areas which monitor the flow of water arising on or directly related to the public lands would have a general impact upon the "improvement, management, use, and protection of the public lands and their resources...." At very least, a strong argument can be made that the research developments generated by surveillance stations and equipment, wherever located, will be of ultimate benefit to all the water resources of the nation, including those on the public lands. Thus, since the Secretary is authorized to accept donations of property for the improvement of the water resources of the public domain and since the benefits derived from the surveillance stations, wherever located, will contribute generally to such improvement, it would appear that the Secretary can accept donations of land for these purposes.

It must be recognized, however, that such a conclusion tends to stretch the authority vested by the statute beyond what was initially contemplated. That being the case, specific legislative authority empowering the Secretary of the Interior to accept donations of property for general purposes relating to the control of water pollution would be desirable.

Acquisition of Sites by Exchange

In the State of Colorado and Wyoming (and other public land states of the West), it would appear possible for the Secretary to acquire surveillance sites by exchange of public lands under his jurisdiction. In this regard, Section 8 of the Taylor Grazing Act, 48 Stat. 1272 (1934), as amended, 43 U.S.C. p. 315g (1964), provides that:

> When public interests will be benefited thereby the Secretary is authorized to accept on behalf of the United States title to any privately owned lands within or without the boundaries of a grazing district, and in exchange therefor to issue patent for not to exceed an equal value of surveyed grazing district land or of unreserved surveyed public land in the same state or within a distance of not more than fifty miles within the adjoining state nearest the base lands.

Under this authority and upon a finding by the Secretary that the "public interests will be benefited" by an exchange of lands in order to establish surveillance stations, his authority to acquire private lands by exchange is clear. However, the statute is of limited application since it applies only in states in which public lands are located. In the context of the present study, the authority would be applicable only in the states of Colorado and Wyoming.

Acquisition of Sites by Purchase or Condemnation

The statutory authority for the purchase or condemnation of property is much more tenuous than that for the exchange of property or the acceptance of donated property. Indeed, in a memorandum prepared by the Assistant Solicitor, Water Pollution Control, Department of the Interior, dated March 10, 1967, it was concluded that "(t)he Secretary of the Interior does not have authority to acquire real property for purpose of his functions and responsibilities under the Federal Water Pollution Control Act...."

As pointed out in that memorandum, the Secretary of the Interior does not have general legislative authority for the purchase of real property. Such authority must be set out for each specific purpose by statute. See 41 U.S.C. p. 14 (1964).

The Federal Water Pollution Control Act, 33 U.S.C.A. p. 466 et seq. (1969 pocket part), authorizes the Secretary to "establish, equip, and maintain field laboratory and research facilities" in certain designated areas of the country, and other areas as he may determine. 33 U.S.C.A. p. 466c(e). While such authority may subsume the authority to purchase lands for the facilities (see 22 Op. Atty. Gen. 665 (1899)), it is unlikely that the authority would extend to the purchase of sites for surveillance stations.

It should be noted that the Assistant Solicitor for Water Pollution Control, in his memorandum of March 16, 1967, supra, concluded that site acquisition for surveillance stations was not authorized by the Act. The basis for this conclusion was apparently the fact that surveillance stations are, essentially, enforcement facilities rather than "field laboratory and research facilities".

The Assistant Solicitor's conclusion appears to be inconsistent with the relevant language of the section which provides that the Secretary "shall establish...laboratory... facilities...for the conduct of...investigations...relating to the prevention and control of water pollution". (Emphasis added.)

Since surveillance facilities are directly related to the "control" of water pollution, it would seem more logical to conclude that they are intended for both enforcement and research purposes. This position is strengthened by the fact that the surveillance stations are not themselves the enforcement mechanism of the act but are, rather, merely the monitoring unit which conducts investigations relating to the control of water pollution. However, in view of the more general language of the section and the prevailing opinion of the Department's Solicitor, it would appear extremely hazardous to rely on the section for the authority to purchase sites for the establishment of surveillance stations.8/

8/ Indeed, as pointed out hereinbefore, the general authority of the Secretary to establish a Federal Water quality surveillance system is not explicit in this section or in the enforcement provisions of the Act, but probably can be inferred from other language of the Act. As in other cases mentioned, however, specific legislative authorization would be preferable. See Section II, supra.

Moreover, since the Act contemplates that "facilities" are to be "located near institutions of higher learning", it appears that the section was probably intended to authorize the establishment of pure research facilities rather than surveillance facilities. It is doubtful, therefore, that the Federal Water Pollution Control Act affords the necessary authority for site acquisition for surveillance facilities.

A second possibility for the requisite authority is the statute authorizing the Secretary to acquire lands for "gaging streams and underground water resources". 56 Stat. 1086 (1942); 43 U.S.C. p. 36b (1964). The statute provides that:

> The Secretary of the Interior may, on behalf of the United States and for use by the Geological Survey in gaging streams and underground water resources, acquire lands by donation or when funds have been appropriated by Congress by purchase or condemnation, but not in excess of ten acres for any one stream gaging station or observation well site. For the same purpose the Secretary of the Interior may obtain easements, licenses, rights-of-way, and leases limited to run for such a period of time or term of years as may be required for the effective performance of the function of gaging streams and underground water resources....

The legislation clearly provides for the acquisition of sites for the gaging of streams. However, the real question is whether the language, "for use by the Geological Survey" precludes the acquisition of sites for use in a surveillance system to be administered by the Federal Water Pollution Control Administration. The answer appears to be in the affirmative.

The legislative history of the statute clearly indicates that the sites are to be used by the Geological Survey in their activities relating to the measurement of streamflow and water supply. (See H. Rept. No. 1847, 77th Cong., 2d Sess., Feb. 28, 1942 and the transmittal letter of the Interior Department contained therein.) Nothing in the language of the statute or its legislative history indicates that the authority is broad enough to empower the Secretary to acquire lands for water pollution surveillance sites.

While it would not be necessary for Congress to have anticipated the need for such sites in the 1942 statute, the specificity of the language tends to limit the usefulness of the statute to the acquisition of sites for use by the Geological Survey.

In this regard, we may _quaere_[9] whether the sites acquired for use by the Geological Survey under this Act may also be used for water quality surveillance by the Federal Water Pollution Control Administration. Again, the specific language of the statute would appear to preclude such use, since the acquired sites are "for use by the Geological Survey in gaging streams and underground water resources...."

It would appear inconceivable that such sites could be used for other Federal purposes as, _e.g._, for military purposes by the Department of Defense or for housing purposes by the Department of Housing and Urban Development. The same logic would appear to apply to any joint use by the Federal Water Pollution Control Administration, even though its use of the sites would be similar to the stream gaging functions performed by the Geological Survey.

Since Congress has required specifically that the sites be used by the Geological Survey for the purposes mentioned in the statute, an intradepartmental transfer of jurisdiction to the Federal Water Pollution Control Administration would appear to contradict the intent of Congress.

Moreover, it is relevant to point out that serious problems would inevitably arise in the appropriations process in Congress if the Federal Water Pollution Control Administration were to acquire lands under this statute. It is not likely that Congress would appropriate funds for site acquisition by the Geological Survey, only to have the sites then used by or transferred to the Federal Water Pollution Control Administration. Indeed, it is unlikely that the Geological Survey itself would be willing to seek and disburse appropriated funds in order to provide survillance sites for another Federal agency in the Department of the Interior.

---

[9] _Quaere_ - question.

The 1950 Reorganization Plan No. 3 (15 Fed. Reg. 3174, 64 Stat. 1262), does not alter the conclusion that authority is lacking under 43 U.S.C., p. 36b to acquire surveillance sites for the Federal Water Pollution Control Administration. The Reorganization Plan merely transferred all functions of Departmental agencies, officers and employees, to the Secretary of the Interior and vested in him with the authority to delegate their performance to the various agencies, officers or employees in the Department. Interpreted broadly, the Reorganization Plan would authorize the Secretary to transfer the stream gaging functions of the Geological Survey to the Federal Water Pollution Control Administration. It would not authorize him, however, to expand the scope of those activities to include water quality surveillance, or to acquire lands for such an expanded program. It is quite likely that Congress would view such an attempted transfer and program expansion as a mere subterfuge designed to circumvent the lack of authority to acquire sites for water quality surveillance.

In summary, it is reasonable to conclude that no statutory authority presently exists for the acquisition of sites for the establishment of a water quality surveillance system.

Site Acquisition under H.R. 4148 and S. 7 and Recommended Legislation

Legislation which has been introduced in the current session of Congress does not appear to provide the necessary authority for surveillance site acquisition. H.R. 4148, an amendment to the Federal Water Pollution Control Act which has passed the House of Representatives, and S. 7, a substantially similar Senate bill, provide that:

> In carrying out the provisions of subsections (a) through (j) of this section relating to the conduct by the Secretary of demonstration projects and the development of field laboratories and research facilities, the Secretary may acquire land and interests therein by purchase, with appropriated or donated funds, by donation, or by exchange for acquired or public lands under his jurisdiction which he classifies as suitable for disposition. The values of the properties so exchanged either shall be

> approximately equal, or if they are not approximately equal, the values shall be equalized by the payment of cash to the grantor or to the Secretary as the circumstances require. H.R. 4148, p. 5 (i), 91st Cong., 1st Sess. (1969).

Essentially, the amendment would clarify the authority of the Secretary to acquire sites for the "field laboratory and research facilities" authorized by section 5(e) of the Federal Water Pollution Control Act. 33 U.S.C.A. p. 466c (e) (1969 pocket part), and for the demonstration projects also authorized by section 5 of the Act.

As discussed, supra, the authority to acquire sites for "field laboratory and research facilities" probably would not be construed to encompass the acquisition of surveillance station sites. Consequently, H.R. 4148 and S.7, if enacted as presently drafted, would be of little assistance in the implementation of a Federal water quality surveillance program.

One possible exception involves the authority granted to the Secretary to acquire lands for "demonstration projects". In this regard, section 5 of the Act authorizes demonstration projects relating to the development of "(i)mproved methods and procedures to identify and measure the effects of pollutants on water uses, including those pollutants created by new technological developments..." 43 U.S.C.A. p. 466c (d) (B) (1969 pocket part). Assuming, arquendo[10], that this language is broad enough to include surveillance stations, H.R. 4148 as presently proposed would authorize the acquisition of land for the stations. However, the language does not appear to be sufficiently encompassing since the authorization is clearly for a "demonstration project" rather than a system for surveillance and enforcement of water quality standards, and since the language relates to the identification and measurement of "the effects of pollutants on water uses" rather than the continuous surveillance and monitoring water quality itself.

---

[10] Arquendo - For the sake of argument or discussion.

For these reasons it appears that neither H.R. 4148 nor S. 7 would provide the necessary authority for the acquisition of sites for water quality surveillance facilities. Therefore, it is recommended that additional legislation be introduced to provide specifically for the establishment of a water quality surveillance system and for the acquisition of necessary sites for surveillance stations. A draft of proposed legislation designed to achieve these objectives is set forth in the Appendix hereto. Such an amendment to the Federal Water Pollution Control Act would provide specific authority for the establishment of a Federal water quality surveillance system, and would authorize the Secretary to acquire the necessary land for the surveillance stations and the necessary equipment for their operation.

ADMISSIBILITY OF EVIDENCE COLLECTED BY SCIENTIFIC EQUIPMENT AND TRANSMITTED BY TELEMETRY DEVICES

As mentioned in the Introduction of the legal portion of this study, the establishment of an efficient water quality surveillance system will assist Federal and State officials in determining compliance and non-compliance with water quality standards established by the various States with the approval of the Secretary of the Interior. Moreover, within the limitations hereinafter described and analyzed, data developed by surveillance facilities may provide early warning of water quality deteriorations and valuable documentation of violations and evidentiary support for enforcement and abatement proceedings.

The use of the surveillance system facilities to detect water quality deterioration and provide informational data respecting complaince, vel non[11], with established water quality standards, poses no real legal problems beyond those involved in location and site acquisition mentioned hereinbefore. On the other hand, use of the scientific data products of such facilities and the introduction of such data as evidenced in abatement proceedings present additional legal considerations. Section 10(c) (5) of the Federal Water Pollution Control Act, 33 U.S.C.A. p. 466g(c) (5), provides that:

> In any suit brought under the provisions of this subsection the court shall receive

---

[11] Vel non - or not.

> in evidence a transcript of the proceedings of the conference and hearing provided for in this subsection, together with the recommendations of the conference and Hearing Board and the recommendations and standards promulgated by the Secretary, and such additional evidence, including that relating to the alleged violation of the standards, as it deems necessary to a complete review of the standards and to a determination of all other issues relating to the alleged violation. The court, giving due consideration to the practicability and to the physical and economic feasibility of complying with such standards, shall have jurisdiction to enter such judgment and orders enforcing such judgment as the public interest and the equities of the case may require.

It is clear from this language that the Act makes no provisions for the admissibility or inadmissibility of particular data gathered and transmitted by automatic devices. Moreover, until specific information is available with regard to the installation and operation of the proposed collection and transmission system, it is not possible to say conclusively that data collected by such a method would be admissible in evidence in pollution abatement and enforcement proceedings. However, the general evidentiary requirements and qualifications which must be met before data collected by scientific instrument may be admitted as evidence, and the corresponding difficulties which may be encountered or anticipated, are hereinafter described and analyzed.

General

Absent the establishment by statute of specific evidentiary requirements applicable to compliance and enforcement proceedings under the Water Pollution Control laws, the general rules of evidence would apply. Such rules are well established in the common law applicable in all State and Federal Courts in this country and will generally be rigidly applied. For this reason, any surveillance facilities installed and operated for the purpose of developing useable evidence in judicial proceedings brought pursuant to the Federal Water Pollution Control Act (see specifically Sections 10(g), (1) & (2)), should be designed and operated in such a way as to meet the technical legal requirements discussed hereinafter.

It is relevant to point out here that the quantum and quality of proof required in judicial proceeding (e.g., enforcement and abatement suits) are generally considerably higher than in administrative proceedings. In this regard, the Administrative Procedure Act (5 U.S.C., Secs. 551 et seq.), which would be applicable to all administrative hearings authorized and conducted pursuant to the Water Pollution Control Act (e.g., conferences convened pursuant to Section 10), specifically provides for the relaxation of the rules of evidence in administrative proceedings.12/ Thus, it may be assumed that data produced by the surveillance system may be useful and admissible in administrative hearings and review proceedings although not competent for introduction in a judicial proceeding.

As a general proposition, admissibility of evidence is, in the first instance, a question to be decided by the trial judge or hearing examiner. He must determine whether the evidence is relevant, material, competent, and not subject to some exclusionary rule of evidence.

Evidence collected or produced by scientific instruments most often must surmount the barrier of competency. Simply stated, competent evidence is that which is fit for the purpose for which it is introduced. Thus, in considering whether data gathered by scientific instrumentation is competent evidence, the trial judge or hearing examiner must determine whether the collected data reliably proves those facts which it purports to prove.

Specific Requirements

The burden of showing the requisite competency is upon the party offering the material in evidence. To meet that burden in the introduction of data collected by scientific instruments, the following qualifications must be met: (1) The type of apparatus must be accepted as dependable

---

12/ Section 7(c) provides, inter alia:
Any oral or documentary evidence may be received, but every agency shall as a matter of policy provide for the exclusion of irrelevant, immaterial, or unduly repetitious evidence and no sanction shall be imposed or rule or order be issued except upon consideration of the whole record or such portions thereof as may be cited by any party and as supported by and in accordance with the reliable, probative, and substantial evidence.

for the purpose for which it has been used by the profession concerned in that branch of science or art; (2) The particular apparatus used must be one constructed according to an accepted type and must be in good condition for accurate work; (3) The person using the apparatus must be one qualified for its use by training and experience. Wigmore, The Science of Judicial Proof, 450 (1937).

To satisfy the first requirement, the offering party must show that the device or method used has gained general acceptance in the particular field in which it belongs as a trustworthy procedure, which is reliably so in all cases. Lindsey v. United States. 237 F. 2d 893, 896 (9th Cir. 1956). This showing may be made in one of the two ways:

Judicial Notice

If the accuracy and reliability of the device is notorious and well established, the judge may take judicial notice of this fact and no further proof is necessary. (See State v. Dantonio, 18 N.J. 50, 115 A. 2d 35 (1955)).

Qualification by Expert Witnesses

This method, which is used when accuracy and reliability is not generally known, requires the presentation of witnesses, who are experts in the particular field and who will testify to the necessary general scientific acceptance and reliability of the device in question. Since, as far as is known, the proposed monitoring and transmission system is novel in many aspects, it would seem that general scientific acceptance could not be shown and would have to be proved by the second method.

The second qualification can be established only by means of expert testimony. An expert in the particular field must offer sufficient evidence to show that the particular apparatus is constructed according to an accepted type. It must also be shown that the apparatus was in good condition for accurate work at the time the data in question was developed. That is, it must be shown that the accuracy of the apparatus was duly tested before, or immediately after, its use. See State v. Dantonio, supra. Generally, this means that the system must be tested for accuracy on the date of the charged violation. See State v. Dantonio, supra; State v. Moffitt, 100 A. 2d 778 (Del. Super. Ct. 1953); and, Carrier v. Commonwealth, 242 S.W. 2d 633 (Ken. Ct. App. 1951).

Under these circumstances, it would appear that some provision must be made for conducting an immediate test for accuracy after the system records a violation, since, unless the system were tested daily, it would be only coincidental that the system was tested on the same day that a violation occurred. This technical legal requirement may, therefore, render remote, unattended surveillance stations unusable for the purpose of providing competent evidence of non-compliance.

The third qualification set forth above would require a showing that the person interpreting the data was duly qualified by training and experience. This may be accomplished by testimony demonstrating the witnesses' training and experience. The judge must determine whether the witness is duly qualified as an expert to testify concerning the data collected and his analysis or interpretation thereof.

Before this evidence would be admitted, however, one additional qualification, applicable to all evidence, must be met; i.e., it must be shown that the evidence does in fact relate to that to which it purports to relate. For example, when intoxication is charged, it must be shown that the sample from which the chemical analysis was made is the sample taken from the one charged with intoxication. The evidence must be traced from its gathering point to its presentation at trial. In the context of a pollution abatement proceeding, it would have to be shown that the data recorded can be traced back to the source of pollution. Again, lack of specific information as to the devices and methods used in developing data renders it impossible to state unequivocally that this requirement can be met.

Moreover, once the surveillance system detects measurable increases in pollution at the metering points, the source of the pollutant must be traced and isolated and the responsible party identified. Samples of discharges must be taken at the source and properly preserved as evidence in connection with abatement and enforcement proceedings.

The identification of the source and the collection of water quality samples from private sewer outfalls or discharge points may raise questions respecting the authority of Federal officials to enter upon private lands for this purpose.

Where such discharges may be measured and adequate samples taken from the river itself or within the boundaries of the navigation servitude, no special problem arises.

However, where discharge occurs on private land and samples cannot be obtained without access to private property, enforcement and abatement will be hampered by the lack of adequate statutory authority to enter upon private lands for the purpose of obtaining evidence of supposed violations. Since our Constitution and laws have historically respected and protected private property rights against unwarranted invasion by the Government and since individual rights are similarly protected against encroachment except under circumstances where a countervailing public interest requires subordination of such private rights, this limitation cannot be lightly regarded.

Short of amending the applicable water pollution control laws to expressly provide for access to private property where Federal officials have reasonable cause to believe a violation has occurred, it will be necessary for such officials to observe the rather cumbersome procedures required in criminal investigations, i.e., obtaining a warrant pursuant to order of the cognizant United States District Court permitting such access.

Since neither the Water Pollution Control Act, 70 Stat. 498 (1956), as amended 33 U.S.C., see 466 et seq. nor related legislation (Federal Water Pollution Control Act Amendments of 1961, 75 Stat. 204 (1961); Water Quality Act of 1965, 79 Stat. 903 (1965); Clean Water Restoration Act of 1966, 80 Stat. 1246 (1966)); or the Federal Water Pollution Control Act of 1970, 84 Stat. 91 (1970) impose criminal sanctions or penalties for violations, the resort to criminal procedures for enforcement and abatement is probably not warranted under this legislation.

However, it should be noted that the Refuse Act of 1899 (Act of March 3, 1899, 30 Stat. 1152, 33 U.S.C., sec. 407) does impose criminal liability for the deposit of refuse in navigable waters. While there have been a number of prosecutions under the Refuse Act over the years, the statute has fallen into disuse until recently.

Nonetheless, the statute does provide a possible vehicle for the development of procedures to enter upon private lands for the purpose of investigating apparent violations of the Refuse Act. Assumedly, if there is reasonable cause to believe that a violation of that Act is occurring, Federal officials, working in cooperation with the local United States Attorney, should be able to secure the necessary warrants which would admit them to private property. The samples and other evidence of violations, would be useful in abatement and enforcement proceedings as well as in any prosecution initiated pursuant to the Refuse Act.

Admittedly, these procedures are cumbersome and somewhat circuitous. But again, short of specific authorization to enter upon private lands by amendment to existing water pollution control laws, such authority appears not to exist.

Suggestions

Examine the possibilities of legislation making data collected by such a system admissible in evidence in an abatement proceeding in Federal Court.

Consider the possibility and efficacy of using the automatic surveillance system as a warning system, following up all violations reported by the system with an on-site manual verification.

MISCELLANEOUS

It is likely that a number of legal problems will arise subsequent to the establishment of the surveillance system.

One problem which may be anticipated involves the liability for damages arising from the operation of the surveillance system. Legal problems could arise in at least two contexts: (1) the liability of the United States to private individuals for damages caused by the facilities and equipment, and (2) the liability of individuals to the United States for damage to the stations and equipment.

Actions by private individuals against the United States would be brought pursuant to the authority of the Federal Tort Claims Act, 62 Stat. 982 (1948) as amended, 28 U.S.C.A. pp. 2671 *et seq*. (1969 pocket part). See also 28 U.S.C.A. p. 1346 (b) (1962 ed.). In general, the Federal Tort Claims Act makes the United States liable for damages occasioned by the negligent or wrongful conduct of its employees while acting within the scope of their employment. It is necessary that negligence by proved; absolute liability alone is not sufficient to sustain a claim. Allison v. United States, 264 F. Supp. 1021 (D.C. Ill. 1967).

Without a lengthy discussion of the various situations which could arise under the surveillance program subjecting the United States to liability, suffice to say that continual precautionary measures should be taken to warn of the existence of the surveillance stations and equipment. Such measures should include regular inspections, fences, signs, adequate lighting, and navigational warning devices. The provision of adequate navigational warning devices should be coordinated with the United States Coast Guard and the various river and harbor authorities of the states and municipalities within the purview of this study.

Regarding the general liability of the United States for damage to vessels caused by obstructions on navigable waters, see Cornell Steamboat Co. v. United States, 247 F. 2d 275 (2d Cir. 1957); Russell, Poling & Co. v. United States, 252 F. 2d 167 (2d Cir. 1958); Pioneer S.S. Co. v. United States, 176 F. Supp. 140 (D.C. Wis. 1959); Otness v. United States, 178 F. Supp. 647 (D.C. Alaska 1959). For the measure of damages in such cases, see Thompson v. Consolidated Gas Electric Light & Power Co., 111 F. Supp. 719 (D.C. Md. 1953).

A case involving the duty of inspection owed by the United State is Adams v. United States, 239 F. Supp. 503 (D.C. Okla. 1965). Regarding the necessity for signs and warning devices, see Molohan v. United States, 206 F. Supp. 388 (D.C. Mont. 1962). As to the necessity for adequate lighting, at least in cases in which trespass is not involved, see Korel v. United States, 246 F. 2d 424 (4th Cir. 1957) and Grant v. United States, 271 F. 2d 651 (2d Cir. 1959). In the only reported case involving the duty of the United States to trespassers, it was held that no action could be maintained. Benson v. United States, 235 F. Supp. 495 (D.C. Alaska 1964).

In cases in which the surveillance stations or equipment are damaged by negligent or wrongful activities of private individuals, the United States has the same right of recovery as a private individual. Jurisdiction is afforded under the general jurisdictional statute authorizing the United States to bring actions in the Federal District Courts. 28 U.S.C.A. p. 1345 (1962 ed.).

The United States Supreme Court has affirmed the right of the United States to sue for theft or destruction of its property. Rex Trailer Co. v. United States, 350 U.S. 148, 151 (1956); Colton v. United States, 52 U.S. 228 (1851).

Other legal problems may arise from what commonly are termed "Acts of God". For example, if the Federal Water Pollution Control Administration were to lease the equipment necessary for monitoring pollutants in the streams, and the equipment were to be damaged or destroyed by flood or other acts of God, the question of liability to the lessor would arise.

Since the Federal Tort Claims Act establishes the liability of the United States only on the basis of negligence or wrongful act, it is doubtful that liability would ensue as the result of an act of God. See discussion, *supra*. However, liability could be predicated on the terms of the lease. Consequently, it would appear advisable, in most instances, for the Federal Water Pollution Control Administration to purchase the surveillance equipment rather than obtaining it on a lease basis.

One final legal problem involves the authority of the Secretary to purchase equipment and supplies necessary for establishing, maintaining and operating the surveillance system.

By virtue of the fact that the Federal Water Pollution Control Act, 33 U.S.C. p466 *et seq*., impliedly authorizes the establishment of a Federal water quality surveillance system (see discussion above), it also provides the general authority for procuring equipment and supplies necessary for the system. While contracting authority is sometimes delineated specifically, see, *e.g.*, section 105 (h) of the Water Quality Improvement Act of 1970, general procurement authority for equipment and supplies is subsumed within the authority to undertake a project or activity. This is the recognized practice within Federal agencies, and is followed consistently in procurement of equipment and supplies. As an example, the Bureau of Reclamation, another procurement and contracting agency within the Department of the Interior, follows this procedure in acquiring equipment and supplies for reclamation projects. They neither rely upon specific legislative authority nor line-item appropriations for such procurement. It follows that the Federal Water Quality Administration possesses similar authority for the purchase of equipment and supplies necessary for water quality surveillance stations.

The general procurement authority of the Department of the Interior derives from Title 41, Chapter 1 and 14 of the Code of Federal Regulations. Section 14-1.401 states that:

> Except as may otherwise be specifically prescribed, the head of each procuring activity has full responsibility for the procurement of supplies, services and construction, including all related matters, under the cognizance of his activity.

Clearly the authority would extend to the Commissioner of the Federal Water Quality Administration and his designated agents, usually referred to as "contracting officers." See 41 CFR p 14-1.404-2 et seq.

In most circumstances, procurement must be carried out pursuant to the procedures for competitive bidding. See Title 41 CFR, Chapter 1, p 1-2.000 et seq. entitled "Procurement by Formal Advertising." As stated in p 1.2.102:

> Procurement shall be made by formal advertising whenever such method is feasible and practicable under the existing circumstances even though such conditions and circumstances would otherwise satisfy the requirements of Subpart 1-3.2. In accordance with this requirement, procurements shall generally be made by soliciting bids from all qualified sources of supplies or services deemed necessary by the contracting officer to assure full and free competition consistent with the procurement of the required property or services.

Certain exceptions, however, are recognized to allow procurement by negotiation. These exceptions are set out in Subpart 1-3.2 of 41 CFR, Chapter 1. These exceptions include as authorized by the Federal Property and Administrative Services Act of 1949: (1) National emergency p 1-3.201; (2) Public exigency p 1-3.202; (3) Purchases not in excess of $2500 p 1-3.203; (4) Personal or professional services p 1-3.204; (5) Services of educational institutions p 1-3.205; (6) Purchases outside the United States p 1-3.206; (7) Medicines or medical supplies p 1-3.207; (8) Property purchased for authorized resale p 1-3.208; (9) Subsistence supplies p 1-3.209; (10) Impracticable to secure competition by formal advertising p 1-3.210; (11) Experimental, developmental or research work p 1-3.211; (12) Purchases which are not to be publicly disclosed p 1-3.212; (13) Technical equipment requiring standardization and interchangeability of parts p 1-3.213; (14) Negotiation after failure of advertising p 1-3.214; (15) Otherwise authorized by law p 1-3.215. Subpart 1-3.3 sets out the requirements for determinations and findings necessary in order to establish one of the exceptions to competitive bidding listed above.

It is likely, with respect to procurement for a Federal water quality surveillance system, that the exceptions to competitive bidding most susceptible of use are: (1) Purchases not in excess of $2500; (2) Services of educational institution; (3) Impracticability of acquiring by competitive bidding; (4) Experimental, developmental or research work; and (5) Technical equipment requiring standardization and interchangeability of parts.

The specific rules for contract negotiation pertaining to the Department of the Interior are set out in Part 14-3 of 41 CFR.

SUMMARY OF LEGAL CONSIDERATIONS

Based upon the foregoing considerations and authorities, we may conclude that the establishment of a Federal water quality surveillance system is necessary and useful in implementing the objectives of the Water Pollution Control laws. Moreover, we may conclude that, although not specifically authorized by the existing laws, the establishment of surveillance facilities is authorized in the general context of the applicable statute. At the same time, we offer the caveat that the existing statute is deficient in several important respects (*e.g.*, specific authority for site acquisition, procurement of materiel, and statutory authority for the admissibility of data developed in enforcement and abatement proceedings) and should be augmented by supplemental legislation.

In light of the fact that the existing law places much of the initial responsibility for enforcement and abatement on State water pollution control agencies, the Federal water pollution surveillance system should be developed in close consultation with cognizant State agencies and officials to minimize the duplicity of facilities and surveillance activities. In this connection, it is suggested that any new legislation proposed should clarify the relative roles of Federal and State officials in the enforcement and abatement process and specifically assign responsibility or provide for coordination of activities in the operation of surveillance facilities.

With respect to the use of data and information developed by surveillance facilities in administrative and judicial proceedings for abatement and enforcement, we have concluded that the applicable evidentiary requirements pose no insuperable barrier to the introduction of such data and information in evidence. At the same time, we have advised herein that the applicable evidentiary requirements should be carefully considered in the design, construction and operation of Federal water quality surveillance facilities.

While the legal portion of this study has been conducted with reference to the three River Basins delineated in the study proposal and contract, a number of the conclusions, observations and recommendations herein set forth will have general applicability in the establishment of a Federal water quality surveillance program on all interstate waters in the United States.

SUGGESTED AMENDMENT

Section 10. Section 10 of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466(g)), is amended:

(a) by redesignating sub-subsections (6) and (7) of subsection (c) as (8) and (9);

(b) by inserting after sub-subsection (5) of subsection (c) two new sub-subsections to read as follows:

> "(6) In carrying out his duties under this section, the Secretary is authorized to establish, equip, and maintain a water quality

surveillance system for the purpose of monitoring the water quality of interstate waters or portions thereof and detecting the existence and nature of pollutants therein.

"(7) The Secretary is authorized, on behalf of the United States and for use by the Federal Water Pollution Control Administration in carrying out the duties under this section, to acquire land or interests therein and necessary access rights by purchase, with appropriated or donated funds, by condemnation, by donation, or by exchange for acquired or public lands under his jurisdiction which he classified as suitable for disposition. The values of the properties so exchanged either shall be approximately equal, or if they are not approximately equal, the values shall be equalized by the payment of cash to the grantor or to the Secretary as the circumstances require."

SECTION 5

SYSTEMS ANALYSIS APPROACH TO SURVEILLANCE PROGRAM DESIGN

To accomplish the objectives of this study, the project team developed a systems analysis framework to guide all activities. Before presenting the specifics of the structure, it will be useful to discuss the rationale and procedures inherent to the systems approach.

The systems approach is the application of the scientific method to problems involving organized systems so as to provide solutions which best serve the purposes of the organization as a whole. The organized system may be an aircraft, a state health-care program, an Air Force Base or a water pollution surveillance system.

Most practitioners of the related disciplines associated with the systems approach would be the first to detail inherent limitations. It is not a cure-all. Rarely do participants agree on whether the approach should be identified as Systems Engineering or Systems Analysis.

The Systems Approach is a more descriptive term in the sense that "engineering" has a hardware connotation and "analysis" implies the separation into parts or elements of something which is already in existence.

The most significant attribute of the Systems Approach is that it can be applied with equal effectiveness to problems of a hardware nature (with well defined boundaries) as to the process of delineating the boundaries of a dilemma such that it can be focused into a problem and then be solved.

THE SYSTEMS APPROACH CONCEPT

The Systems Approach is an orderly way of appraising a situation. Its application results in answers to questions such as:

- How many elements are there to the problem of concern?
- What cause and effect relationships exist among the elements?

- What trade-offs may be required among resources, once they are defined?

- What functions need to be performed?

It has been stated that the approach is appropriate to the broad definition of a system. The majority of previous applications has been to aerospace problems. Here, applications have been characterized by programs with the following orders of difficulty:

- A complex goal involving a major system composed of hardware, computer programs, facilities, personnel, and data.

- A dynamic environment in which changes affect identified objectives, constraints and criteria.

- Limited resources for development which encompass funds, manpower, facilities and time.

For programs such as those above, application of the Systems Approach early in the conceptual phase helps to minimize the probability of oversight or the occurrence of what is often called "appraisal gaps." This is achieved by using a structured technique to continuously identify and assess the impact of changing objectives, constraints, and hardware criteria on required resources, i.e., technologies, personnel and facilities.

The Systems Approach is a process which involves a series of steps:

- Define the purpose of the system.

- Establish specific objectives for the system-objectives against which the performance of the system can be measured.

- Identify the constraints which limit freedom in trying to achieve the objectives.

- Propose alternative means of attaining the objectives.

- Formalize the criteria for evaluating the alternatives.

- Compare the alternatives and choose the best one according to the accepted criteria.

- Implement the selected alternative.

- Check to see if the objectives have been reached.

Briefly stated, the logic of the Systems Approach is "deductive/inductive." The thinking path is in the form of a closed loop that has distinct stages for timely inputs and continuous feedback. Thinking evolves in cyclic fashion, as it progresses from general objectives to plans, then back to refining objectives and to detailing plans further.

Figure 6 illustrates the steps to be taken within each cycle of the approach. It is significant to note the iterative nature of the procedure as well as the interfacing nature of the specific individual cycles.

The direction and intent of this project was to study current situations existing within the three river basins, FWPCA standards, state standards, present surveillance measures, and projected requirements and integrate all into one comprehensive interrelated system. Applying the rationale discussed above to describe the interrelated system, measurements of the impact of variations in any of those elements noted above can be made.

Before describing the development of the analysis framework, attention should be given to the sequence of cycles illustrated at the top of Figure 6. Therefore, four cycles are identified and consist of:

- Mission Definition Cycle

- System Definition Cycle

- System Elements Definition Cycle

- Advanced Planning Cycles for Technologies, Personnel and Facilities

This project addresses itself to the delineation of the first cycle - the mission. The analysis framework with all of its inherent parameters and considerations is geared to guiding the definition of the water quality surveillance mission. It is general and is equally applicable to any river basin which might be considered.

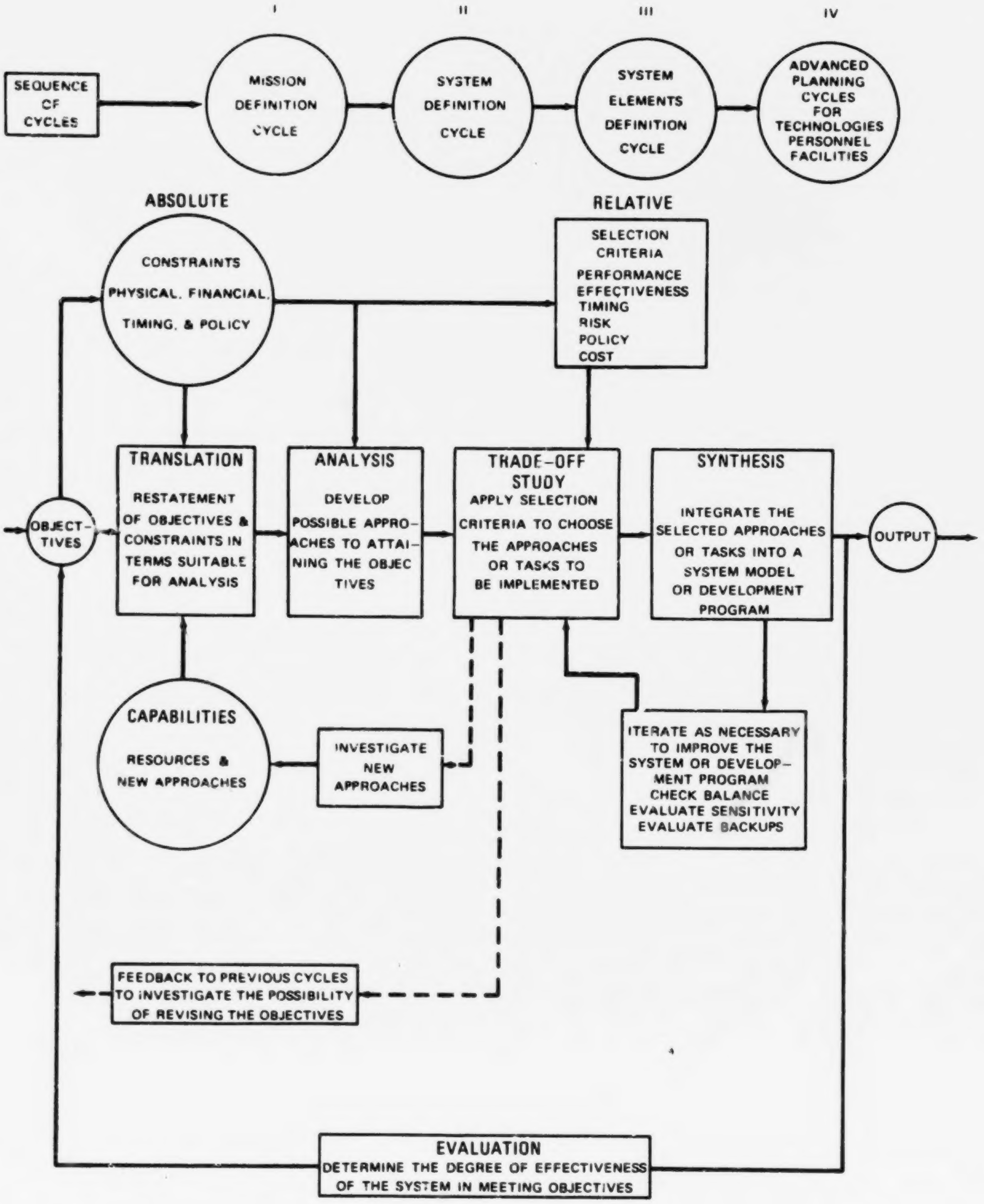

I
II
III
IV
SEQUENCE OF CYCLES
MISSION DEFINITION CYCLE
SYSTEM DEFINITION CYCLE
SYSTEM ELEMENTS DEFINITION CYCLE
ADVANCED PLANNING CYCLES FOR TECHNOLOGIES PERSONNEL FACILITIES
ABSOLUTE
CONSTRAINTS
PHYSICAL, FINANCIAL, TIMING, & POLICY
RELATIVE
SELECTION CRITERIA
PERFORMANCE
EFFECTIVENESS
TIMING
RISK
POLICY
COST
OBJECTIVES
TRANSLATION
RESTATEMENT OF OBJECTIVES & CONSTRAINTS IN TERMS SUITABLE FOR ANALYSIS
ANALYSIS
DEVELOP POSSIBLE APPROACHES TO ATTAINING THE OBJECTIVES
TRADE-OFF STUDY
APPLY SELECTION CRITERIA TO CHOOSE THE APPROACHES OR TASKS TO BE IMPLEMENTED
SYNTHESIS
INTEGRATE THE SELECTED APPROACHES OR TASKS INTO A SYSTEM MODEL OR DEVELOPMENT PROGRAM
OUTPUT
CAPABILITIES
RESOURCES & NEW APPROACHES
INVESTIGATE NEW APPROACHES
ITERATE AS NECESSARY TO IMPROVE THE SYSTEM OR DEVELOPMENT PROGRAM
CHECK BALANCE
EVALUATE SENSITIVITY
EVALUATE BACKUPS
FEEDBACK TO PREVIOUS CYCLES TO INVESTIGATE THE POSSIBILITY OF REVISING THE OBJECTIVES
EVALUATION
DETERMINE THE DEGREE OF EFFECTIVENESS OF THE SYSTEM IN MEETING OBJECTIVES

FIGURE 6
STEPS WITHIN THE SYSTEMS APPROACH

Cycles 2, 3 and 4 are not addressed within this report. Phase II of the study specifically is oriented toward defining the water quality surveillance system to be implemented within one river basin. It is defined by qualitatively and quantitatively implementing the analysis framework for the environment and conditions to be found in that basin. Because the framework is general, certain portions will not be applicable to a specific circumstance. The ultimate result of Cycle 2 is a specific water quality surveillance system tailored to a prescribed environment. Cycles 3 and 4 sequentially serve to define the system in succeedingly greater detail.

SYSTEMS ANALYSIS FRAMEWORK FOR SURVEILLANCE SYSTEMS PROGRAMS

The systems analysis framework was formulated in three phases:

Phase One

With prescribed objectives and a discipline of approach in mind, the initial task involved a literature search. This was accomplished to identify as many considerations and parameters as possible which contribute to the selection, placement and operation of a water quality surveillance system.

In the interest of defining considerations and parameters which could be separated and analyzed as a group, ten categories were established. The titles for these categories were rather arbitrarily established and are considered relatively unimportant. However, of significance, is the grouping of like and closely interrelated considerations and parameters. It was found that natural and logical patterns developed which became, in part, the rationale for the systems analysis frameworks submitted within this report.

- Lifetime Operational Concept
- System Design and Performance Characteristics
- Development and Test Concept
- Training Concept

- Facilities Survey
- Manufacturing Concept
- Threat Concept
- Stress Conditions and Emergency Buildup Concept
- System Effectiveness
- Logistic Support Concept

Phase Two

With a glossary of parameters and considerations completed, Phase Two involved the preparation of a functional flow block diagram. Figure 7 illustrates the results. The objectives of this study as previously set forth in Figures 1, 2, 3 and 4 served as milestones to accomplishment. They were integrated with and expanded by the content of the key word Indexing Guide developed in the literature search.

It is significant to note that Figure 7 incorporates a form of decision logic in that evaluations are required at specific stages of the analysis. Where decisions are required, alternative paths are indicated dependent upon the result.

At any point in the analysis illustrated in Figure 7, expansion of content may be located in the supporting text.

Phase Three

Figure 7 together with the supporting text comprises an integrated analysis in that all pertinent considerations inherent to the establishment of a water quality surveillance system are sequentially evaluated.

To illustrate how the broad analytical framework as represented by Figure 7 is implemented, the determination of the location of water quality surveillance stations within a river basin has been detailed. Those considerations pertinent to the problem of location have been isolated and keyed by number to the framework. (See Figure 8.)

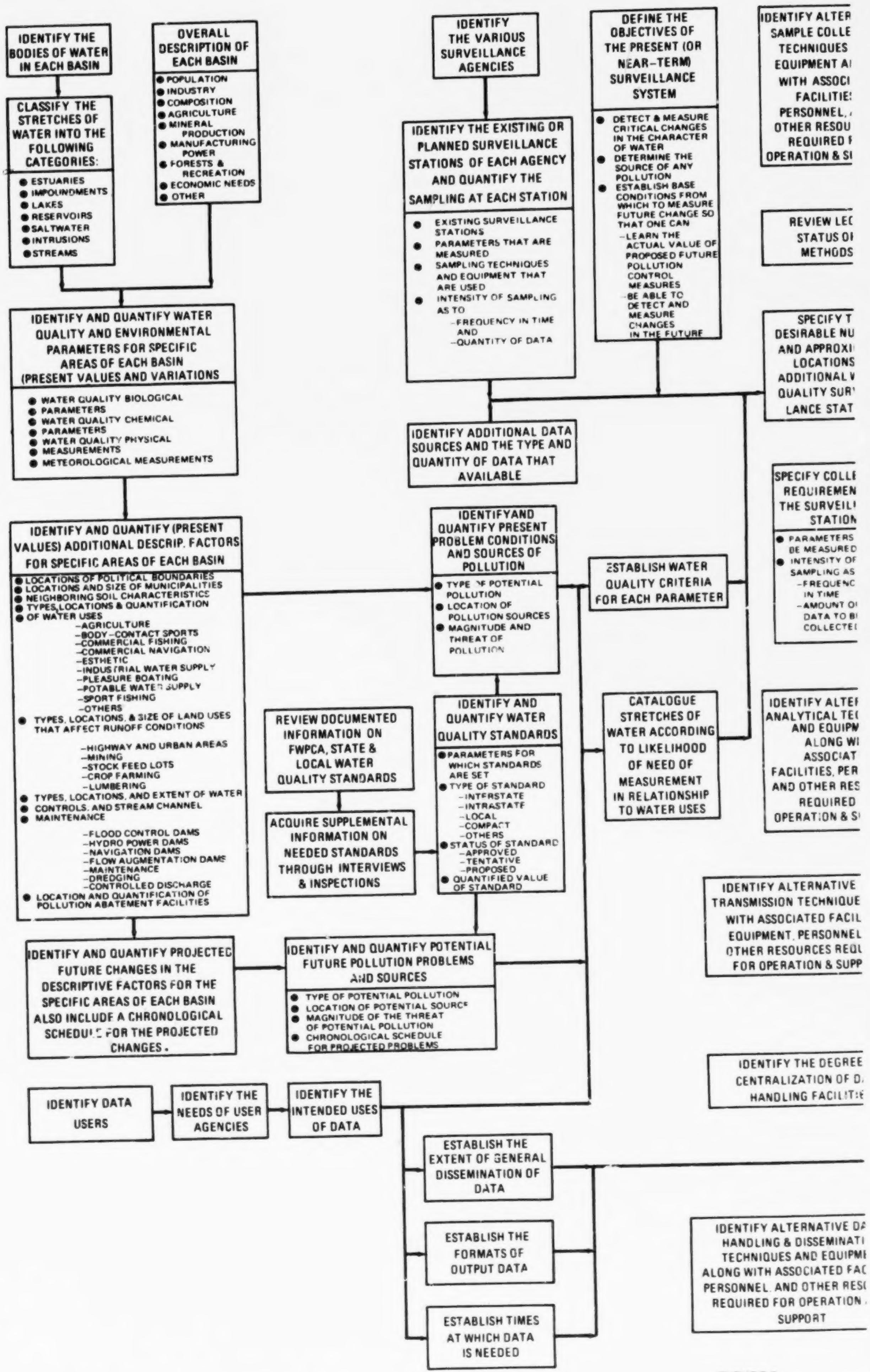
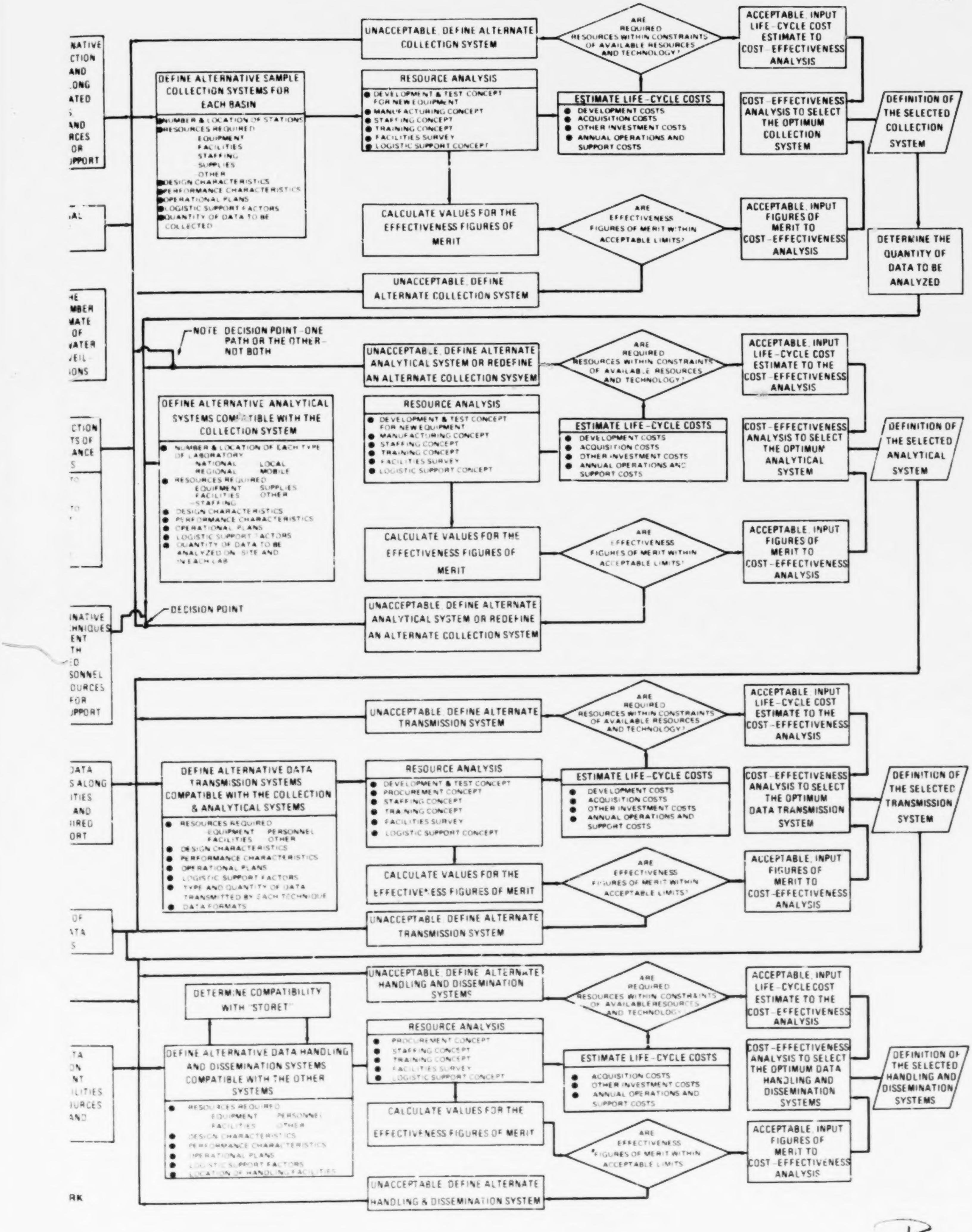
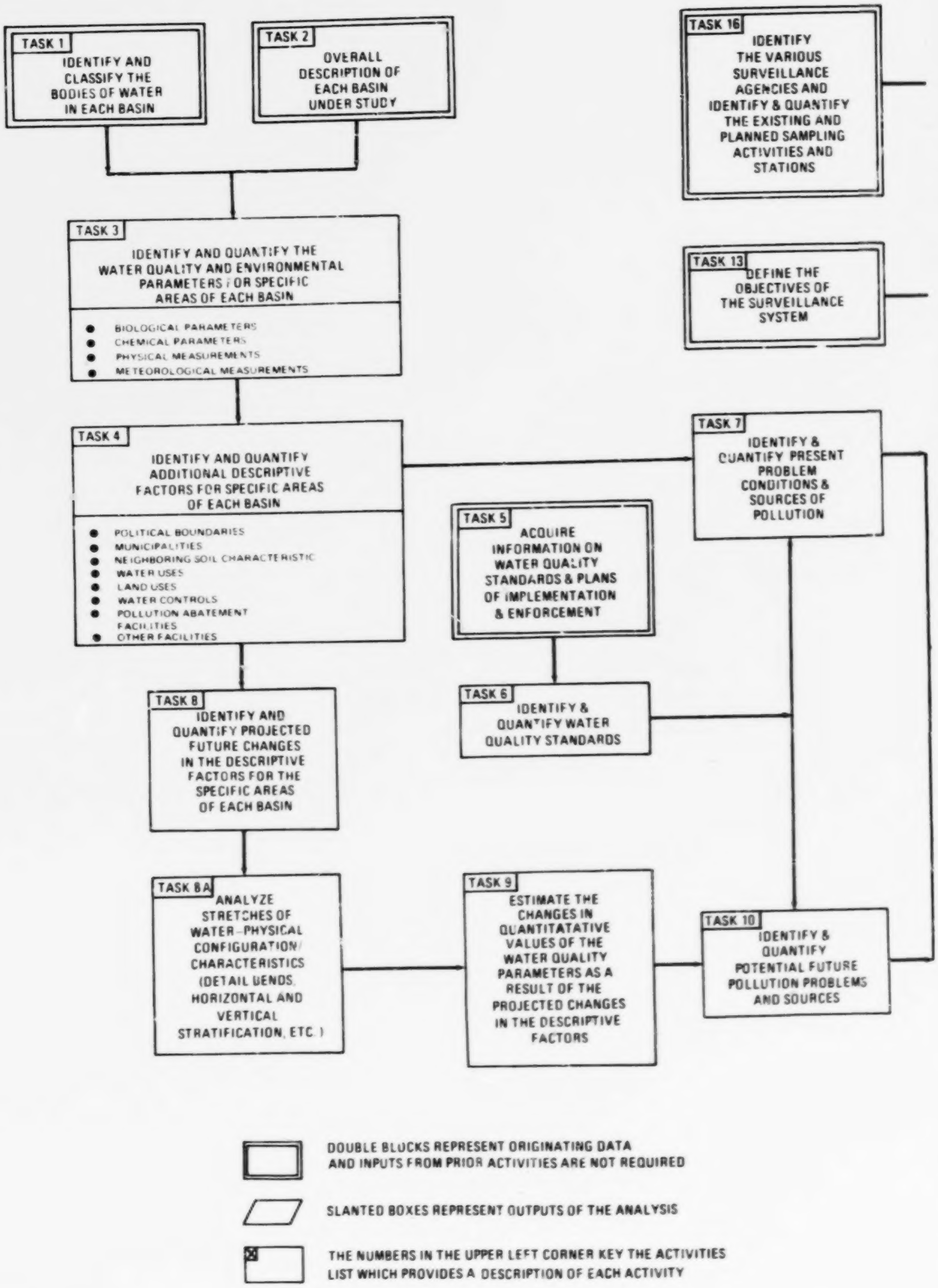

IDENTIFY THE BODIES OF WATER IN EACH BASIN
CLASSIFY THE STRETCHES OF WATER INTO THE FOLLOWING CATEGORIES:
● ESTUARIES
● IMPOUNDMENTS
● LAKES
● RESERVOIRS
● SALTWATER
● INTRUSIONS
● STREAMS
OVERALL DESCRIPTION OF EACH BASIN
● POPULATION
● INDUSTRY
● COMPOSITION
● AGRICULTURE
● MINERAL PRODUCTION
● MANUFACTURING POWER
● FORESTS & RECREATION
● ECONOMIC NEEDS
● OTHER
IDENTIFY AND QUANTIFY WATER QUALITY AND ENVIRONMENTAL PARAMETERS FOR SPECIFIC AREAS OF EACH BASIN (PRESENT VALUES AND VARIATIONS
● WATER QUALITY BIOLOGICAL
● PARAMETERS
● WATER QUALITY CHEMICAL
● PARAMETERS
● WATER QUALITY PHYSICAL
● MEASUREMENTS
● METEOROLOGICAL MEASUREMENTS
IDENTIFY AND QUANTIFY (PRESENT VALUES) ADDITIONAL DESCRIP. FACTORS FOR SPECIFIC AREAS OF EACH BASIN
● LOCATIONS OF POLITICAL BOUNDARIES
● LOCATIONS AND SIZE OF MUNICIPALITIES
● NEIGHBORING SOIL CHARACTERISTICS
● TYPES, LOCATIONS & QUANTIFICATION
● OF WATER USES
-AGRICULTURE
-BODY-CONTACT SPORTS
-COMMERCIAL FISHING
-COMMERCIAL NAVIGATION
-ESTHETIC
-INDUSTRIAL WATER SUPPLY
-PLEASURE BOATING
-POTABLE WATER SUPPLY
-SPORT FISHING
-OTHERS
● TYPES, LOCATIONS, & SIZE OF LAND USES THAT AFFECT RUNOFF CONDITIONS
-HIGHWAY AND URBAN AREAS
-MINING
-STOCK FEED LOTS
-CROP FARMING
-LUMBERING
● TYPES, LOCATIONS, AND EXTENT OF WATER
● CONTROLS, AND STREAM CHANNEL
● MAINTENANCE
-FLOOD CONTROL DAMS
-HYDRO POWER DAMS
-NAVIGATION DAMS
-FLOW AUGMENTATION DAMS
-MAINTENANCE
-DREDGING
-CONTROLLED DISCHARGE
● LOCATION AND QUANTIFICATION OF POLLUTION ABATEMENT FACILITIES
IDENTIFY AND QUANTIFY PROJECTED FUTURE CHANGES IN THE DESCRIPTIVE FACTORS FOR THE SPECIFIC AREAS OF EACH BASIN ALSO INCLUDE A CHRONOLOGICAL SCHEDULE FOR THE PROJECTED CHANGES.
IDENTIFY THE VARIOUS SURVEILLANCE AGENCIES
IDENTIFY THE EXISTING OR PLANNED SURVEILLANCE STATIONS OF EACH AGENCY AND QUANTIFY THE SAMPLING AT EACH STATION
● EXISTING SURVEILLANCE STATIONS
● PARAMETERS THAT ARE MEASURED
● SAMPLING TECHNIQUES AND EQUIPMENT THAT ARE USED
● INTENSITY OF SAMPLING AS TO
-FREQUENCY IN TIME AND
-QUANTITY OF DATA
DEFINE THE OBJECTIVES OF THE PRESENT (OR NEAR-TERM) SURVEILLANCE SYSTEM
● DETECT & MEASURE CRITICAL CHANGES IN THE CHARACTER OF WATER
● DETERMINE THE SOURCE OF ANY POLLUTION
● ESTABLISH BASE CONDITIONS FROM WHICH TO MEASURE FUTURE CHANGE SO THAT ONE CAN
-LEARN THE ACTUAL VALUE OF PROPOSED FUTURE POLLUTION CONTROL MEASURES
-BE ABLE TO DETECT AND MEASURE CHANGES IN THE FUTURE
IDENTIFY ALTER SAMPLE COLLE TECHNIQUES EQUIPMENT A WITH ASSOCI FACILITIE PERSONNEL, OTHER RESOU REQUIRED OPERATION & S
REVIEW LEC STATUS O METHODS
SPECIFY T DESIRABLE NU AND APPROXI LOCATIONS ADDITIONAL W QUALITY SUR LANCE STAT
IDENTIFY ADDITIONAL DATA SOURCES AND THE TYPE AND QUANTITY OF DATA THAT AVAILABLE
SPECIFY COLLE REQUIREMEN THE SURVEIL STATION
● PARAMETERS BE MEASURED
● INTENSITY OF SAMPLING AS
-FREQUENC IN TIME
-AMOUNT O DATA TO B COLLECTE
IDENTIFYAND QUANTIFY PRESENT PROBLEM CONDITIONS AND SOURCES OF POLLUTION
● TYPE OF POTENTIAL POLLUTION
● LOCATION OF POLLUTION SOURCES
● MAGNITUDE AND THREAT OF POLLUTION
ESTABLISH WATER QUALITY CRITERIA FOR EACH PARAMETER
REVIEW DOCUMENTED INFORMATION ON FWPCA, STATE & LOCAL WATER QUALITY STANDARDS
ACQUIRE SUPPLEMENTAL INFORMATION ON NEEDED STANDARDS THROUGH INTERVIEWS & INSPECTIONS
IDENTIFY AND QUANTIFY WATER QUALITY STANDARDS
● PARAMETERS FOR WHICH STANDARDS ARE SET
● TYPE OF STANDARD
-INTERSTATE
-INTRASTATE
-LOCAL
-COMPACT
-OTHERS
● STATUS OF STANDARD
-APPROVED
-TENTATIVE
-PROPOSED
● QUANTIFIED VALUE OF STANDARD
CATALOGUE STRETCHES OF WATER ACCORDING TO LIKELIHOOD OF NEED OF MEASUREMENT IN RELATIONSHIP TO WATER USES
IDENTIFY ALTE ANALYTICAL TE AND EQUIPM ALONG WI ASSOCIAT FACILITIES, PER AND OTHER RES REQUIRED OPERATION & S
IDENTIFY AND QUANTIFY POTENTIAL FUTURE POLLUTION PROBLEMS AND SOURCES
● TYPE OF POTENTIAL POLLUTION
● LOCATION OF POTENTIAL SOURCE
● MAGNITUDE OF THE THREAT OF POTENTIAL POLLUTION
● CHRONOLOGICAL SCHEDULE FOR PROJECTED PROBLEMS
IDENTIFY ALTERNATIVE TRANSMISSION TECHNIQUE WITH ASSOCIATED FACIL EQUIPMENT, PERSONNEL OTHER RESOURCES REQU FOR OPERATION & SUPP
IDENTIFY THE DEGREE CENTRALIZATION OF D HANDLING FACILITIE
IDENTIFY DATA USERS
IDENTIFY THE NEEDS OF USER AGENCIES
IDENTIFY THE INTENDED USES OF DATA
ESTABLISH THE EXTENT OF GENERAL DISSEMINATION OF DATA
ESTABLISH THE FORMATS OF OUTPUT DATA
ESTABLISH TIMES AT WHICH DATA IS NEEDED
IDENTIFY ALTERNATIVE DA HANDLING & DISSEMINATI TECHNIQUES AND EQUIPM ALONG WITH ASSOCIATED FA PERSONNEL, AND OTHER RES REQUIRED FOR OPERATION SUPPORT

FIGURE 7

GENERAL SYSTEMS ANALYSIS FRAMEWO


NATIVE
CTION
AND
.ONG
ATED
AND
RCES
OR
JPPORT
DEFINE ALTERNATIVE SAMPLE COLLECTION SYSTEMS FOR EACH BASIN
NUMBER & LOCATION OF STATIONS
RESOURCES REQUIRED
EQUIPMENT
FACILITIES
STAFFING
SUPPLIES
OTHER
DESIGN CHARACTERISTICS
PERFORMANCE CHARACTERISTICS
OPERATIONAL PLANS
LOGISTIC SUPPORT FACTORS
QUANTITY OF DATA TO BE COLLECTED
UNACCEPTABLE, DEFINE ALTERNATE COLLECTION SYSTEM
ARE REQUIRED RESOURCES WITHIN CONSTRAINTS OF AVAILABLE RESOURCES AND TECHNOLOGY?
ACCEPTABLE, INPUT LIFE-CYCLE COST ESTIMATE TO COST-EFFECTIVENESS ANALYSIS
RESOURCE ANALYSIS
DEVELOPMENT & TEST CONCEPT FOR NEW EQUIPMENT
MANUFACTURING CONCEPT
STAFFING CONCEPT
TRAINING CONCEPT
FACILITIES SURVEY
LOGISTIC SUPPORT CONCEPT
ESTIMATE LIFE-CYCLE COSTS
DEVELOPMENT COSTS
ACQUISITION COSTS
OTHER INVESTMENT COSTS
ANNUAL OPERATIONS AND SUPPORT COSTS
COST-EFFECTIVENESS ANALYSIS TO SELECT THE OPTIMUM COLLECTION SYSTEM
DEFINITION OF THE SELECTED COLLECTION SYSTEM
CALCULATE VALUES FOR THE EFFECTIVENESS FIGURES OF MERIT
ARE EFFECTIVENESS FIGURES OF MERIT WITHIN ACCEPTABLE LIMITS?
ACCEPTABLE, INPUT FIGURES OF MERIT TO COST-EFFECTIVENESS ANALYSIS
DETERMINE THE QUANTITY OF DATA TO BE ANALYZED
UNACCEPTABLE, DEFINE ALTERNATE COLLECTION SYSTEM
AL
HE
MBER
MATE
OF
VATER
VEIL-
IONS
NOTE DECISION POINT-ONE PATH OR THE OTHER-NOT BOTH
UNACCEPTABLE, DEFINE ALTERNATE ANALYTICAL SYSTEM OR REDEFINE AN ALTERNATE COLLECTION SYSYEM
ARE REQUIRED RESOURCES WITHIN CONSTRAINTS OF AVAILABLE RESOURCES AND TECHNOLOGY?
ACCEPTABLE, INPUT LIFE-CYCLE COST ESTIMATE TO THE COST-EFFECTIVENESS ANALYSIS
CTION
TS OF
ANCE
S
TO
TO
DEFINE ALTERNATIVE ANALYTICAL SYSTEMS COMPATIBLE WITH THE COLLECTION SYSTEM
NUMBER & LOCATION OF EACH TYPE OF LABORATORY
NATIONAL
LOCAL
REGIONAL
MOBILE
RESOURCES REQUIRED
EQUIPMENT
SUPPLIES
FACILITIES
OTHER
STAFFING
DESIGN CHARACTERISTICS
PERFORMANCE CHARACTERISTICS
OPERATIONAL PLANS
LOGISTIC SUPPORT FACTORS
QUANTITY OF DATA TO BE ANALYZED ON-SITE AND IN EACH LAB
RESOURCE ANALYSIS
DEVELOPMENT & TEST CONCEPT FOR NEW EQUIPMENT
MANUFACTURING CONCEPT
STAFFING CONCEPT
TRAINING CONCEPT
FACILITIES SURVEY
LOGISTIC SUPPORT CONCEPT
ESTIMATE LIFE-CYCLE COSTS
DEVELOPMENT COSTS
ACQUISITION COSTS
OTHER INVESTMENT COSTS
ANNUAL OPERATIONS AND SUPPORT COSTS
COST-EFFECTIVENESS ANALYSIS TO SELECT THE OPTIMUM ANALYTICAL SYSTEM
DEFINITION OF THE SELECTED ANALYTICAL SYSTEM
CALCULATE VALUES FOR THE EFFECTIVENESS FIGURES OF MERIT
ARE EFFECTIVENESS FIGURES OF MERIT WITHIN ACCEPTABLE LIMITS?
ACCEPTABLE, INPUT FIGURES OF MERIT TO COST-EFFECTIVENESS ANALYSIS
DECISION POINT
INATIVE
CHNIQUES
ENT
TH
ED
SONNEL
OURCES
FOR
JPPORT
UNACCEPTABLE, DEFINE ALTERNATE ANALYTICAL SYSTEM OR REDEFINE AN ALTERNATE COLLECTION SYSTEM
UNACCEPTABLE, DEFINE ALTERNATE TRANSMISSION SYSTEM
ARE REQUIRED RESOURCES WITHIN CONSTRAINTS OF AVAILABLE RESOURCES AND TECHNOLOGY?
ACCEPTABLE, INPUT LIFE-CYCLE COST ESTIMATE TO THE COST-EFFECTIVENESS ANALYSIS
DATA
S ALONG
ITIES
AND
IRED
ORT
DEFINE ALTERNATIVE DATA TRANSMISSION SYSTEMS COMPATIBLE WITH THE COLLECTION & ANALYTICAL SYSTEMS
RESOURCES REQUIRED
EQUIPMENT
PERSONNEL
FACILITIES
OTHER
DESIGN CHARACTERISTICS
PERFORMANCE CHARACTERISTICS
OPERATIONAL PLANS
LOGISTIC SUPPORT FACTORS
TYPE AND QUANTITY OF DATA TRANSMITTED BY EACH TECHNIQUE
DATA FORMATS
RESOURCE ANALYSIS
DEVELOPMENT & TEST CONCEPT
PROCUREMENT CONCEPT
STAFFING CONCEPT
TRAINING CONCEPT
FACILITIES SURVEY
LOGISTIC SUPPORT CONCEPT
ESTIMATE LIFE-CYCLE COSTS
DEVELOPMENT COSTS
ACQUISITION COSTS
OTHER INVESTMENT COSTS
ANNUAL OPERATIONS AND SUPPORT COSTS
COST-EFFECTIVENESS ANALYSIS TO SELECT THE OPTIMUM DATA TRANSMISSION SYSTEM
DEFINITION OF THE SELECTED TRANSMISSION SYSTEM
CALCULATE VALUES FOR THE EFFECTIVENESS FIGURES OF MERIT
ARE EFFECTIVENESS FIGURES OF MERIT WITHIN ACCEPTABLE LIMITS?
ACCEPTABLE, INPUT FIGURES OF MERIT TO COST-EFFECTIVENESS ANALYSIS
OF
ATA
S
UNACCEPTABLE, DEFINE ALTERNATE TRANSMISSION SYSTEM
UNACCEPTABLE, DEFINE ALTERNATE HANDLING AND DISSEMINATION SYSTEMS
ARE REQUIRED RESOURCES WITHIN CONSTRAINTS OF AVAILABLE RESOURCES AND TECHNOLOGY?
ACCEPTABLE, INPUT LIFE-CYCLE COST ESTIMATE TO THE COST-EFFECTIVENESS ANALYSIS
DETERMINE COMPATIBILITY WITH "STORET"
TA
ON
NT
ILITIES
URCES
AND
DEFINE ALTERNATIVE DATA HANDLING AND DISSEMINATION SYSTEMS COMPATIBLE WITH THE OTHER SYSTEMS
RESOURCES REQUIRED
EQUIPMENT
PERSONNEL
FACILITIES
OTHER
DESIGN CHARACTERISTICS
PERFORMANCE CHARACTERISTICS
OPERATIONAL PLANS
LOGISTIC SUPPORT FACTORS
LOCATION OF HANDLING FACILITIES
RESOURCE ANALYSIS
PROCUREMENT CONCEPT
STAFFING CONCEPT
TRAINING CONCEPT
FACILITIES SURVEY
LOGISTIC SUPPORT CONCEPT
ESTIMATE LIFE-CYCLE COSTS
ACQUISITION COSTS
OTHER INVESTMENT COSTS
ANNUAL OPERATIONS AND SUPPORT COSTS
COST-EFFECTIVENESS ANALYSIS TO SELECT THE OPTIMUM DATA HANDLING AND DISSEMINATION SYSTEMS
DEFINITION OF THE SELECTED HANDLING AND DISSEMINATION SYSTEMS
CALCULATE VALUES FOR THE EFFECTIVENESS FIGURES OF MERIT
ARE EFFECTIVENESS FIGURES OF MERIT WITHIN ACCEPTABLE LIMITS
ACCEPTABLE, INPUT FIGURES OF MERIT TO COST-EFFECTIVENESS ANALYSIS
RK
UNACCEPTABLE, DEFINE ALTERNATE HANDLING & DISSEMINATION SYSTEM

B


TASK 1
IDENTIFY AND CLASSIFY THE BODIES OF WATER IN EACH BASIN
TASK 2
OVERALL DESCRIPTION OF EACH BASIN UNDER STUDY
TASK 16
IDENTIFY THE VARIOUS SURVEILLANCE AGENCIES AND IDENTIFY & QUANTIFY THE EXISTING AND PLANNED SAMPLING ACTIVITIES AND STATIONS
TASK 3
IDENTIFY AND QUANTIFY THE WATER QUALITY AND ENVIRONMENTAL PARAMETERS FOR SPECIFIC AREAS OF EACH BASIN
BIOLOGICAL PARAMETERS
CHEMICAL PARAMETERS
PHYSICAL MEASUREMENTS
METEOROLOGICAL MEASUREMENTS
TASK 13
DEFINE THE OBJECTIVES OF THE SURVEILLANCE SYSTEM
TASK 4
IDENTIFY AND QUANTIFY ADDITIONAL DESCRIPTIVE FACTORS FOR SPECIFIC AREAS OF EACH BASIN
POLITICAL BOUNDARIES
MUNICIPALITIES
NEIGHBORING SOIL CHARACTERISTIC
WATER USES
LAND USES
WATER CONTROLS
POLLUTION ABATEMENT FACILITIES
OTHER FACILITIES
TASK 7
IDENTIFY & QUANTIFY PRESENT PROBLEM CONDITIONS & SOURCES OF POLLUTION
TASK 5
ACQUIRE INFORMATION ON WATER QUALITY STANDARDS & PLANS OF IMPLEMENTATION & ENFORCEMENT
TASK 6
IDENTIFY & QUANTIFY WATER QUALITY STANDARDS
TASK 8
IDENTIFY AND QUANTIFY PROJECTED FUTURE CHANGES IN THE DESCRIPTIVE FACTORS FOR THE SPECIFIC AREAS OF EACH BASIN
TASK 8A
ANALYZE STRETCHES OF WATER–PHYSICAL CONFIGURATION/ CHARACTERISTICS (DETAIL BENDS, HORIZONTAL AND VERTICAL STRATIFICATION, ETC.)
TASK 9
ESTIMATE THE CHANGES IN QUANTITATATIVE VALUES OF THE WATER QUALITY PARAMETERS AS A RESULT OF THE PROJECTED CHANGES IN THE DESCRIPTIVE FACTORS
TASK 10
IDENTIFY & QUANTIFY POTENTIAL FUTURE POLLUTION PROBLEMS AND SOURCES
DOUBLE BLOCKS REPRESENT ORIGINATING DATA AND INPUTS FROM PRIOR ACTIVITIES ARE NOT REQUIRED
SLANTED BOXES REPRESENT OUTPUTS OF THE ANALYSIS
THE NUMBERS IN THE UPPER LEFT CORNER KEY THE ACTIVITIES LIST WHICH PROVIDES A DESCRIPTION OF EACH ACTIVITY

ANALYTICAL FRAM

A

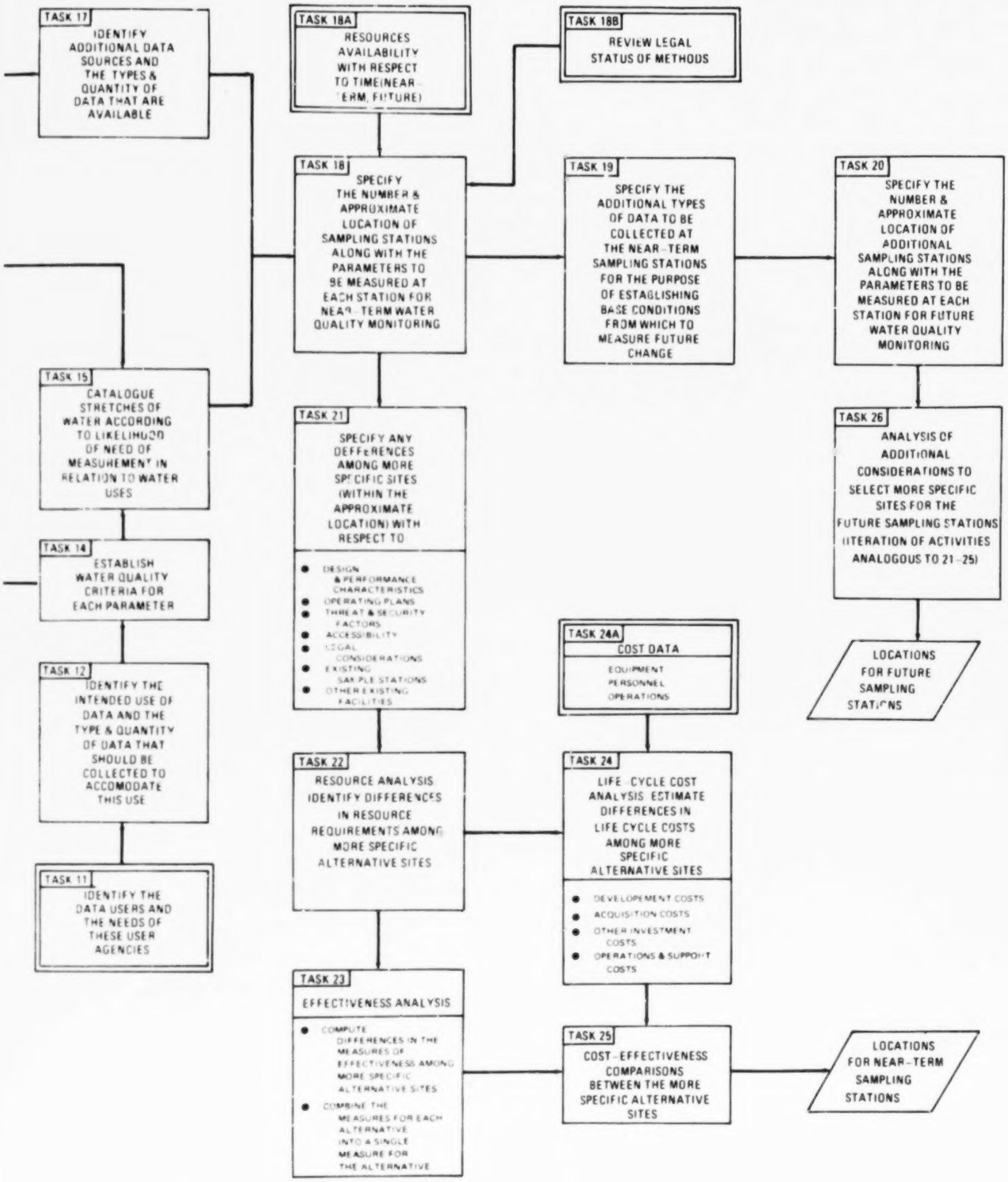

TASK 17 IDENTIFY ADDITIONAL DATA SOURCES AND THE TYPES & QUANTITY OF DATA THAT ARE AVAILABLE
TASK 18A RESOURCES AVAILABILITY WITH RESPECT TO TIME(NEAR-TERM, FUTURE)
TASK 18B REVIEW LEGAL STATUS OF METHODS
TASK 18 SPECIFY THE NUMBER & APPROXIMATE LOCATION OF SAMPLING STATIONS ALONG WITH THE PARAMETERS TO BE MEASURED AT EACH STATION FOR NEAR-TERM WATER QUALITY MONITORING
TASK 19 SPECIFY THE ADDITIONAL TYPES OF DATA TO BE COLLECTED AT THE NEAR-TERM SAMPLING STATIONS FOR THE PURPOSE OF ESTABLISHING BASE CONDITIONS FROM WHICH TO MEASURE FUTURE CHANGE
TASK 20 SPECIFY THE NUMBER & APPROXIMATE LOCATION OF ADDITIONAL SAMPLING STATIONS ALONG WITH THE PARAMETERS TO BE MEASURED AT EACH STATION FOR FUTURE WATER QUALITY MONITORING
TASK 15 CATALOGUE STRETCHES OF WATER ACCORDING TO LIKELIHOOD OF NEED OF MEASUREMENT IN RELATION TO WATER USES
TASK 21 SPECIFY ANY DEFFERENCES AMONG MORE SPECIFIC SITES (WITHIN THE APPROXIMATE LOCATION) WITH RESPECT TO
● DESIGN & PERFORMANCE CHARACTERISTICS
● OPERATING PLANS
● THREAT & SECURITY FACTORS
● ACCESSIBILITY
● LEGAL CONSIDERATIONS
● EXISTING SAMPLE STATIONS
● OTHER EXISTING FACILITIES
TASK 26 ANALYSIS OF ADDITIONAL CONSIDERATIONS TO SELECT MORE SPECIFIC SITES FOR THE FUTURE SAMPLING STATIONS (ITERATION OF ACTIVITIES ANALOGOUS TO 21-25)
TASK 14 ESTABLISH WATER QUALITY CRITERIA FOR EACH PARAMETER
TASK 24A COST DATA
EQUIPMENT
PERSONNEL
OPERATIONS
LOCATIONS FOR FUTURE SAMPLING STATIONS
TASK 12 IDENTIFY THE INTENDED USE OF DATA AND THE TYPE & QUANTITY OF DATA THAT SHOULD BE COLLECTED TO ACCOMODATE THIS USE
TASK 22 RESOURCE ANALYSIS IDENTIFY DIFFERENCES IN RESOURCE REQUIREMENTS AMONG MORE SPECIFIC ALTERNATIVE SITES
TASK 24 LIFE-CYCLE COST ANALYSIS ESTIMATE DIFFERENCES IN LIFE CYCLE COSTS AMONG MORE SPECIFIC ALTERNATIVE SITES
● DEVELOPEMENT COSTS
● ACQUISITION COSTS
● OTHER INVESTMENT COSTS
● OPERATIONS & SUPPORT COSTS
TASK 11 IDENTIFY THE DATA USERS AND THE NEEDS OF THESE USER AGENCIES
TASK 23 EFFECTIVENESS ANALYSIS
● COMPUTE DIFFERENCES IN THE MEASURES OF EFFECTIVENESS AMONG MORE SPECIFIC ALTERNATIVE SITES
● COMBINE THE MEASURES FOR EACH ALTERNATIVE INTO A SINGLE MEASURE FOR THE ALTERNATIVE
TASK 25 COST-EFFECTIVENESS COMPARISONS BETWEEN THE MORE SPECIFIC ALTERNATIVE SITES
LOCATIONS FOR NEAR-TERM SAMPLING STATIONS

FIGURE 8

'EWORK FOR SELECTING SURVEILLANCE STATIONS LOCATIONS

B

The water quality surveillance station location analysis is presented as an example. Comparable treatment of other specific areas of concern is similarly accomplished.

The project team has addressed itself to the area of program plans and the development of data and procedures for the identification of water quality surveillance goals and objectives. These then, when systematically developed, will ultimately provide the basis for the establishment of a consistent program policy.

The requirement for a consistent policy for the fulfillment of FWPCA areas of responsibilities, as charged by the Congress, remained constantly superimposed over the design of a systems analysis framework. In review, these areas are:

- The monitoring of interstate streams and the provision of reliable data from which to measure and assess compliance with interstate water quality standards.
- The provision of reliable data from which to define long-term trends and overall changes in water quality.
- To provide data to the Congress which will enable the assessment of current and proposed legislative programs in a manner which will provide for the optimum utilization of appropriated funds.

Accordingly, all developed procedures and techniques remained general so as to be compatible with any eventual and specific area of geographical interest. Alternately stated, a common basis for analysis was established. The results of such analysis is strictly dependent upon the specifics of the geographical area under study.

In addition to the obvious benefit of being able to compare the needs, goals, and objectives for varying pollution environments, the analysis framework would establish the following:

- Justification for Federal facility expenditures
- The most appropriate areas for research studies
- Water quality trends
- Compliance with established water quality standards
- Surveillance system performance implications

To understand the needs and objectives of a system, its purpose must be clearly understood. The project team strove to develop the means to identify what a surveillance system must do for a variety of possible situations and environments. The developed framework will subsequently guide the quantification of the correct parameters which, in turn, may be amalgamated into a firm set of requirements for implementation of the system.

Generalized Framework

Lifetime Operational Concept

The Operational Concept is a statement pertaining to a water quality surveillance system which outlines: the guidance necessary to define system support requirements, installations and staffing concepts and requirements, and the manner with which the system would be operated. Further, this category of considerations would address; the description of the system and its application, the organizational structure where applicable, operational capabilities, the geographical area of intended operations and its intended use.

For the most part, this category of considerations would guide the selection of areas for additional study where the information for decision-making is not available. Such studies, would not be conducted independently of each other. Many areas of overlap exist and information feedback and transfusion among these supporting studies must occur if the results are to be technically compatible, valid and credible.

Identification of bodies of water in each basin. (See categories 1., 2., and 3. in the Indexing Guide.) (p. 36 - 41)

Classification of the stretches of water within each basin by type:

- Estuaries
- Impoundments
- Lakes
- Reservoirs

- Saltwater intrusions
- Streams

Overall description of each basin in terms of factors which determine present and potential water use of various kinds.

- Population (detailed by such factors as age and income levels)
- Industry composition
- Agriculture
- Mineral production
- Manufacturing
- Production
- Forests and recreation areas
- Economic parameters
- Other

Identification and quantification of water quality and environmental parameters for specific areas of each basin.

- Biological water quality parameters (See Category 8. in Indexing Guide)
- Chemical water quality parameters (See Category 9. in Indexing Guide)
- Physical water quality measurements (See Category 10. in Indexing Guide)
- Meteorological measurements (See Category 10. in Indexing Guide)

Additional descriptive factors for specific areas of each basin.

- Location of political boundaries
- Location and size of municipalities
- Neighboring soil characteristics

- Type, location, and size of land uses that affect runoff
    - Highways and urban areas
    - Mining
    - Stock feed lots
    - Crop farming
    - Lumbering
- Type, location, and quantification of water uses (See Category 4. in Indexing Guide)
- Type, location, and size of dams
    - Flood control dams
    - Hydro-power dams
    - Navigation dams
    - Flow augmentation dams
- Type, location, and extent of water controls and stream channel maintenance
    - Maintenance dredging
    - Controlled discharge (irrigation canals, navigation, recreation, industrial supply)

Identification and quantification of the threat of potential pollution sources.

- Types of potential pollution sources (See Category 13. in Indexing Guide)
- Location of potential sources
- Magnitude of the threat of potential pollution

Identification and quantification of pollution abatement facilities

- Type of pollution abatement (See Category 14. in Indexing Guide)

- Location of pollution abatement facilities
- Water quality parameters which are affected
- Amount of water treated

Identification and quantification of water quality standards

- Water quality parameters for which standards are set
- Type and status of standards (See Category 11. in Indexing Guide)
- Quantified values for the identified standards

Geography of the sampling stations, operational bases, maintenance facilities, laboratories, and data handling facilities.

Description of system operations plans and the role of each of the major subsystems in the total surveillance system structure

- Intended activities of each subsystem
- Interfaces between activities of different subsystems
- On-site analysis vs. sample shipping
- Form of data to be transmitted
- Data transmission facilities
- Type of analysis in local lab vs. analysis in central lab, etc.
- Intended utilization and activity rates for major subsystems and equipment

Organizational structures and size of operating units, direct support, indirect support, and other logistics support

- Number of instrument stations
- Number of manual sampling stations
- Number of local laboratories

- Number of central laboratories
- Number and type of supporting organizations

Staffing concepts for the various operating, direct support, indirect support, and other logistic support organizations during normal and emergency operations.

- Number, skill mix, and rank (or experience level) of collection personnel
- Number, skill mix, and rank of automatic monitoring station maintenance personnel
- Number, skill mix, and rank of analytical personnel
- Number, skill mix, and rank of data handling personnel
- Number, skill mix, and rank of administrative and support personnel
- Salaries and other expenses for specific skills

Identification of the various surveillance agencies and their activities, personnel, and other resources involved (See Category 12. in Indexing Guide).

Quantification of the size of the production buys of primary mission equipment

- Production quantities

Identification and quantification of inherited assets to be utilized for the system.

- Type, size, and dollar value of inherited facilities
- Number of personnel and types of skills inherited
- Type, quantity, and dollar value of inherited equipment

System Design and Performance Characteristics

This category of considerations and parameters would include those necessary to select the appropriate system configuration and operational requirements given that we know the demands to be imposed upon the system. Treatment is at a level which enables the analyst to direct his attention to subsystems and individual components. It is essential that sufficient data exist to enable a decision as to whether the system of concern is an existing system, a modified existing system, new state-of-the-art system, or an advanced configuration.

Overall system design characteristics

- Types of sampling stations (automatic, manual, composite)
- Types of laboratories (national, regional, local, mobile)
- Modes of data transmission
- Types of data handling
- Design features
- Types of major equipment
    - Types of sampling instruments, analytical equipment, data handling equipment and the level of technology incorporated in the design including identification of elements that are off-the-shelf, state-of-the-art, or require research and development
- State-of-the-art
    - Measured by the greater or lesser number of engineering man-hours which must be expanded because the system is highly advanced or in the state-of-the-art
    - Identification of purchased parts and fabricated parts
    - Types and quantities of raw material for fabrication
    - Physical size of major equipment
    - Three view drawings of system configurations
    - Mobility, servicing, and storage requirements
    - Personnel required and the required skills

  - Environmental conditions the system is designed to withstand

Overall system performance characteristics

- Water quality parameters that are to be monitored
- Sampling frequency
- Sample preparation and handling capacity
- Sample shipping capacity and time
- Data analysis capacity and time
- Data transmission capacity and time
- Data handling and dissemination capacity and time
- Accuracy of measurements
- Expected service life of components total number of operational hours
- Design reliability
  - Mean time between failures of major equipment and probability of equipment successfully accomplishing its assigned function
- Parts failure rates
- Design repairability and maintainability
  - Mean time to restore major equipment to operational status; personnel and other resources required to maintain specified number of operational equipment
- Design serviceability
- Major overhaul requirements and schedule
- Inherent deterioration rates
  - Percent of total stocks and spares lost yearly due to inherent deterioration (caused by failure to be used within life expectancy of the item)

Subsystem identification and design description

Subsystem performance characteristics

Subsystem component identification and design descriptions

Identification and design description of any specialized equipment required for system operation or support

Estimate of number of engineering man-hours for system design

Development and Test Concept

The development and test category of information addresses a Validation and Verification of system/subsystem configurations superimposed over system operational requirements. In terms of cost and the level of support required to maintain an operational system, quality control during development and subsequent testing is significantly important. Specifically, the following would guide and detail the analysis which identifies the nature, complexity and composition of a development and test program. In part, information accumulated would address the nature and level of technology that must be developed during a potential Research and Development program, and an assessment of the risk involved in achieving identified technology goals.

Length of R&D program

Information on the nature and level of technology that must be developed during the R&D program and an assessment of the risk involved in achieving the technology goals on schedule

- Follow-on or substantially new and advanced system
- Identification of the system elements that are state-of-the-art
- Identification of the system elements that require substantial R&D

Testing

- Type, number, and duration of major development tests required by standards, regulations, or otherwise planned in the development program such as:

        - Component tests
        - Subsystem tests
        - Integrated system tests under controlled environment
        - Integrated system tests in operating environment
    - Location of test sites
    - Number of systems and subsystems needed to conduct test program
    - Identification of test program management
    - Type and quantity of test instrumentation
    - Kinds and quantities of test data, data reduction, data analysis
    - Identification of any special equipment for the test program
    - Identification of any special facility requirements for the development and test program

Inherited assets that can be used in the development and test program

- Type of development and testing facilities inherited and number of square feet of each type of facility
- Number and type of test instruments and instrument packages inherited (e.g., recording devices)
- Number and type of electrical, electronic, mechanical, structural, and other test support equipment inherited (e.g., power supplies and generators)

Sequence and relative schedule for development items and tests

Estimated number of engineering man-hours for development

Training Concept

An analysis of system operation, maintenance, and human factors are required to define the skill levels providing for efficient system operation and maintenance. Studies designed to determine training requirements would take into account the quantity and type of resources required. Emphasis is directed, within this category, to men, skills and equipment.

Skill requirements

- List of skills required
- Appropriate mix of skills needed
- Appropriate mix of ranks (or experience levels) needed

Personnel turnover rates associated with the various personnel ranks (or experience levels) and/or skill categories

Initial and replacement training plan and curricula

- Type and number of courses to bring new personnel up to required skill levels
- Duration of initial training program (in months)
- Length of courses (in weeks)
- Number of personnel that can be trained in a given time period
- Type and quantity of training equipment, simulators, and nonconsumable aids needed in course
- Type and quantity of consumables (manuals, workbooks, etc.) needed for each trainee

Transitional training plan and curricula

- Type and number of courses to bring existing personnel up to required skill levels
- Duration of transitional training program
- Length of courses (in weeks)

- Number of people that can be trained in a given time period
- Type and quantity of training equipment, simulators, and nonconsumable aids needed in course
- Type and quantity of consumables needed for each trainee

Kinds, quantity, and frequency of any annual training needed to maintain skill proficiency

- Number of training activities
- Time involved (hours per month or year)
- Resources consumed

Training facilities requirements

- Type, size, and number of training facilities
- Any special requirements on the geographic location and environment for training facilities

Identification and quantification of any direct or indirect support needed for the training program

- Type of support needed for the training program
- Quantity and cost of support needed for the training program

Kind and amount of training that must be contracted for

- Type of training to be contracted for
- Amount and cost of training to be contracted for

Facilities Survey

Substantial facilities would be required to support a water quality surveillance system which incorporates the full range of capabilities considered within this report. Data transmission, data and sample analysis, data storage, sample acquisition and maintenance all require facilities which heavily affect system acquisition and operating cost. Total benefits to accrue to the public from the installation of a water quality surveillance system would be assessed in recognition of total costs. The largest portion of these costs are incurred in personnel, equipment and facilities. Following considerations would scope the facilities required.

Extent of available existing usable facilities

- Type and number of facilities inherited
- Size of each facility inherited (sq. ft.)
- Dollar value of inherited facilities

Amount and cost of modification, augmentation, and modernization of existing facilities for use in the new system

Nature and extent of new and replacement facilities that need to be built for the operation and support of the new system

- Type, size, number, and cost of new and replacement facilities

Nature and extent of shared facilities

- Type, size, number, and cost of facilities, equipment, and personnel that are shared
- Dollar value of savings due to sharing

Evaluation of alternative facility sites and determination of cost factors for various site alternatives

- Alternative sites for various types of facilities
- Effectiveness factors associated with alternatives
- Cost factors associated with alternatives

Factors relating to site activation and refurbishment

Requirements for specialized support equipment

- Type and amount of specialized support equipment needed at various types of facilities
- Cost estimates for such equipment

Requirements for temporary facilities for time-limited emergency periods

- Type, duration, location, and frequency of stress conditions under which temporary facilities are needed
- Type, size, and location of temporary facilities

Facilities deterioration and facilities deterioration and obsolescence

- Life expectancy of facilities
- Rate at which major repairs of facilities are needed-percent of initial investment per year
- Percent depreciation per year

Manufacturing Concept

In the past, surveillance agencies have for the most part limited their efforts towards surveillance instrumentation to the writing of performance specifications. They had not supported research and development efforts in this area to any large degree. Leadership has not been generated at the Federal level to insure that suitable equipment and facilities can be produced as needed. This is particularly true for currently unmonitorable parameters.

Such a commercially marginal market should receive guidance and support from its largest potential user. Currently available water quality surveillance equipment has not been developed under any general guideline, but has been assembled from units developed for other specific uses.

Within the range of data categories included within this report, manufacturing considerations fall sequentially later in the overall rationale. The plan for system implementation, system design and performance characteristics, development and test, and training are factors to be considered in evaluating the impact of production abilities. The information presented in the following pages would guide an evaluation of production implications. This project team maintains a position that manufacturing, as a category of consideration, has a significant impact on the acquisition of a surveillance system which exhibits the greatest effectiveness for the least cost. This is particularly true when we contemplate water quality surveillance systems which are pushing or advancing beyond the current state-of-the-art.

For example, the range of considerations include: the identification of a schedule for development, test, production, training, total program milestones, program planning and budgeting leadtimes, contract dates, production and contract leadtimes, comparative pricing, first configuration completion date and initial operational capability data.

Cumulative procurement quantity

- Total number of units of primary system equipment to be procured

Possible production rates, production buildup, and duration of production run

- Number of units of primary mission equipment produced each month at various points in the production run

- Length of time needed to produce total procurement quantity (months, weeks)

Production delivery schedule and buildup of units in the system.

Quantification of number of procurement sources required (if applicable) and description and cost of tooling required for development and production.

Analysis of adequacy of available production facilities in the time period of concern.

Analysis of producibility of system to be costed and analysis of impact of state-of-the-art fabrication techniques needed for manufacture of system.

Lead times for procurement of replacement equipment and supplies.

Additional appropriate quantitative data must then be added, by assumption, on such items as:

- Labor cost per hour

- Raw material cost per lb., ft^2, or ft^3.

- Other direct costs (e.g., travel, perdiem, reproduction, etc.)

- Direct cost burden rates

- Contractor fees, profits

Threat Concept

The category of threat includes considerations which pertain to the identification of conditions which threaten damage to the primary system or other equipment or in some other way threaten normal operation. Included are: the suppressibility of threats, time periods of stress, and the extent of the degradations. In addition to serving as a vital input to the system design analysis, the parameters itemized on the following pages are factors to be considered in; cost analysis, determination of maintenance requirements, system redundancy analysis, and others.

Probabilities of occurrence of the threat conditions

Nature and extent of threatened damage

- Type of possible damage from each threat condition

- Expected degradation of performance of the system due to threat conditions

Probability of damage given the occurrence of threat conditions

Repair factors

- Time required to restore system to normal performance

- Resources and cost required to restore system to normal performance

Stress Conditions and Emergency Buildup Concept

Identification and quantification of the nature and capacity of the LOC (line-of-communication) needed to support the operational system. Data would be needed on the LOC capacity level maintained under normal conditions, the capacity level required to support activities under stress conditions, the source of necessary surge capacity to convert from normal to emergency operations, and the rate of increasing the LOC pipeline capacity.

- Modes of transmission
- Geographic locations
- Capacity for transmitting samples and data during normal conditions
- Capacity for transmitting samples and data under stress conditions
- Capacity for moving supplies and other resources under normal conditions
- Capacity for moving supplies and other resources under stress conditions
- Source of necessary surge to support emergencies
- Rates of increasing capacities during surge buildup

Identification and quantification of amount and rate of increase of logistic support required to convert from normal to emergency operations.

Quantification of staffing and skill factors for normal and stress levels, the rate of increase in staffing during conversion from normal to stress levels, and the source of personnel for the surge buildup.

- Number, skills, and experience levels of personnel utilized during normal conditions
- Number, skills, and experience levels of additional personnel needed due to increase of activity rates during stress conditions
- Rate of increase in personnel during surge buildup
- Source of additional personnel during surge buildup
- Training requirements and rates for additional personnel

Quantification of the expected utilization rates of operating personnel and direct and indirect support personnel during normal operations, buildup, and emergency operations.

- Number of shifts per day
- Available manhours per week per man

Quantification of the expected utilization rates during normal operations, surge buildup, and emergency operations for primary and specialized equipment.

- Operating hours per week for primary and specialized equipment during normal conditions
- Additional equipment to be used under emergency operations (type and quantity)
- Operating hours per week for existing equipment during surge buildup
- Operating hours per week for equipment during emergency operations

Quantification of the expected changes in consumption rates of supplies, parts, etc., when converting from normal to emergency operations.

- Consumption rates (quantity and cost per day) during normal operations
- Consumption rates (quantity and cost per day) during emergency operations

Quantification of the emergency reserve plans for setting aside equipment, material, and supplies to use in an emergency or during surge buildup activities.

- Equipment held in reserve as a percent of equipment in the operational system
- Number of days of stock of material and supplies held in reserve

System Effectiveness

The category of system effectiveness addresses; the ability of the system to perform defined tasks and to attain specific objectives (capability), the ability of the system to remain operational for the required period (dependability), and the probability that the system will be operational and ready for service when a demand is placed upon it. (Availability) The ability to assess a water quality surveillance system for these factors involves an integration of information derived from most of the other categories discussed within this report. More than any other category, system effectiveness provides the basis for the assessment of alternative systems, the degrees of suitability for a given system and the ability to perform a comparative analysis.

Force size during normal conditions.

- Number and type of stations
- Number of associated personnel

Force size during emergencies.

- Number and type of stations
- Number of associated personnel

Information on achievable utilization rates during both normal and emergency operations.

- Continuous or periodic monitoring
- Frequency and duration of sampling if periodic
- Ratio of operating time to downtime if continuous

Quantification of estimated attrition rates for primary system equipment during normal and emergency operations and under threat conditions.

Quantification of equipment reliability during normal and emergency operations.

- Meantime between failure for various equipment and components
- Reliability (probability of being operational) of equipment and components vs operating time
- Probability of equipment successfully accomplishing its assigned function (detecting pollution, measuring flow rate, temperature, depth, etc.)

Quantification of system availability under normal and stress conditions

- Number or percent of total primary mission equipment and personnel available to perform their assigned task at any point in time

Quantification of survivability under threat conditions

Quantification of equipment damage rates during normal and emergency operations and under threat conditions.

- Type, quantity, and seriousness of damage to primary system equipment per increment of time under specific environmental conditions

Maintenance float

- Average number of units of primary mission equipment needed in maintenance activities to keep specified number of units operationally ready
- Average number of units of other equipment needed in maintenance to keep specified number of such equipment available for use

Expected effectiveness

- Probability of detecting significant change in any of the various water quality parameters
- Time after significant change before it is detected
- Probability of determining the source of pollution

Logistic Support Concept

Emphasis within the logistic support category of factors is directed to water quality surveillance system maintenance. For this system, as for any other we might contemplate, system maintenance requirements are an important input to system availability and dependability - two of the attributes of system effectiveness. The entire range of considerations which fall within this category contribute significantly to system acquisition and operational costs. Included are spares and repair parts, service - both periodic and random, and others. It should be noted that factors itemized within the following pages relate not only to sensors and data acquisition equipment but the laboratories, data analysis equipment and data transmission components as well.

Maintenance and Other Direct Support

Identification and quantification of the kind and number of maintenance and other direct support organizations required.

- Types of maintenance organizations, i.e., field station, office or laboratory

Identification and quantification of personnel and personnel skills required for maintenance, servicing, and inspection of the primary equipment.

- Maintenance personnel skills required
- Number of personnel for each skill

Identification and quantification of any specialized maintenance equipment required for servicing and inspection.

- Types of special maintenance equipment required
- Amount and cost of special equipment needed

Identification and quantification of other equipment and vehicles needed for direct support, such as watercraft, landcraft, aircraft, general purpose maintenance equipment, special clothing and similar individual equipment, and other unit and organizational equipment.

- Types of direct support equipment required
- Amount and cost of such equipment

Identification and quantification of: initial inventories of stocks; the prorata share of supplies; the amount of supplies in the pipeline from the manufacture to the depot. Initial stocks would include initial ready supplies of parts, materials, lubricants, etc. required.

- Type, quantity, and cost of initial inventories
- Type, quantity, and cost of supplies in the pipeline
- Number of months or days of supply at expected consumption rate

Identification and quantification of long leadtime spares for primary, specialized, and other equipment must be specified

- Identify those spares which require a long leadtime for procurement
- Length of leadtime in months
- Quantity and cost of such spares held in reserve
- Number of spares consumed per unit time under normal conditions

Mechanical policy to account for routine scheduled and unscheduled maintenance, minor and major overhauls, and inspections.

- Type of maintenance and servicing performed on-site
- Type of maintenance performed at local maintenance stations
- Frequency of on-site inspections and servicing
- Preventive maintenance plan
- Overhaul schedule
- Type, number, extent and frequency of system component replacement modules as opposed to component repair

Deterioration and lost rates for stocks and spares

- Percent of total stocks and spares lost yearly due to environmental conditions
- Percent of total stocks and spares lost yearly due to other causes

Quantification of annual consumption of labor and material used or equivalent contracted services for maintenance and repair of the operating units primary, specialized, and other equipment

- Maintenance manhours per year
- Quantity and cost of parts consumed per year
- Maintenance manhours per overhaul
- Quantity and cost of parts consumed per overhaul

Indirect Support

The items falling under the indirect support category are also part of "Logistics Support." However, for convenience they are treated separately in this discussion. If the indirect support organizations and associated staffing have not already been identified in the "Lifetime Operational Concept," the cost analyst will be seeking quantitative information on this subject. Depending on the size, nature and locations of the system operating units and bases, the following type information is pertinent.

Identification and quantification of indirect support organizations and services such as laboratory administration, supply operations and facilities maintenance.

Quantification of staffing, skills, and rank or experience level for indirect support and/or ratio of direct manpower to indirect support manpower.

Other Logistic Support

The remaining elements of logistic support that are of interest to the cost analyst involve the following items.

Quantification of warehouse facilities, inventory management personnel, and other associated inventory storage and management expenses (including personnel training), which are associated with the system's supply of replacement equipment, maintenance materials, operating supplies, etc.

Identification of the resupply geography and means of transportation for replacement equipment, stocks, spares, parts, and other supplies.

- Location of supplies

- Modes of transportation

Identification and quantification of equipment and supplies to be purchased through local business as opposed to regular supply system acquisition.

- Type of supplies purchased through local business
- Quantity and cost of supplies purchased through local businesses

Surveillance Station Locations Selection

The activity list on the following pages describes a framework for the analysis to select the optimum locations for surveillance stations. This framework identifies a sequential step-by-step series of activities which, when accomplished will yield the optimum locations for surveillance stations. The accompanying diagram indicates the flow of information in the analysis. (See Figure 9)

The key to the analysis is that approximate locations are first determined by factors such as basin characteristics, water quality conditions and standards, intended data uses, and surveillance objectives. More specific alternative sites (within the approximate location for each station) are then compared through a cost-effectiveness analysis of additional considerations such as resources, performance characteristics, accessibility, and existing facilities.

Activity List

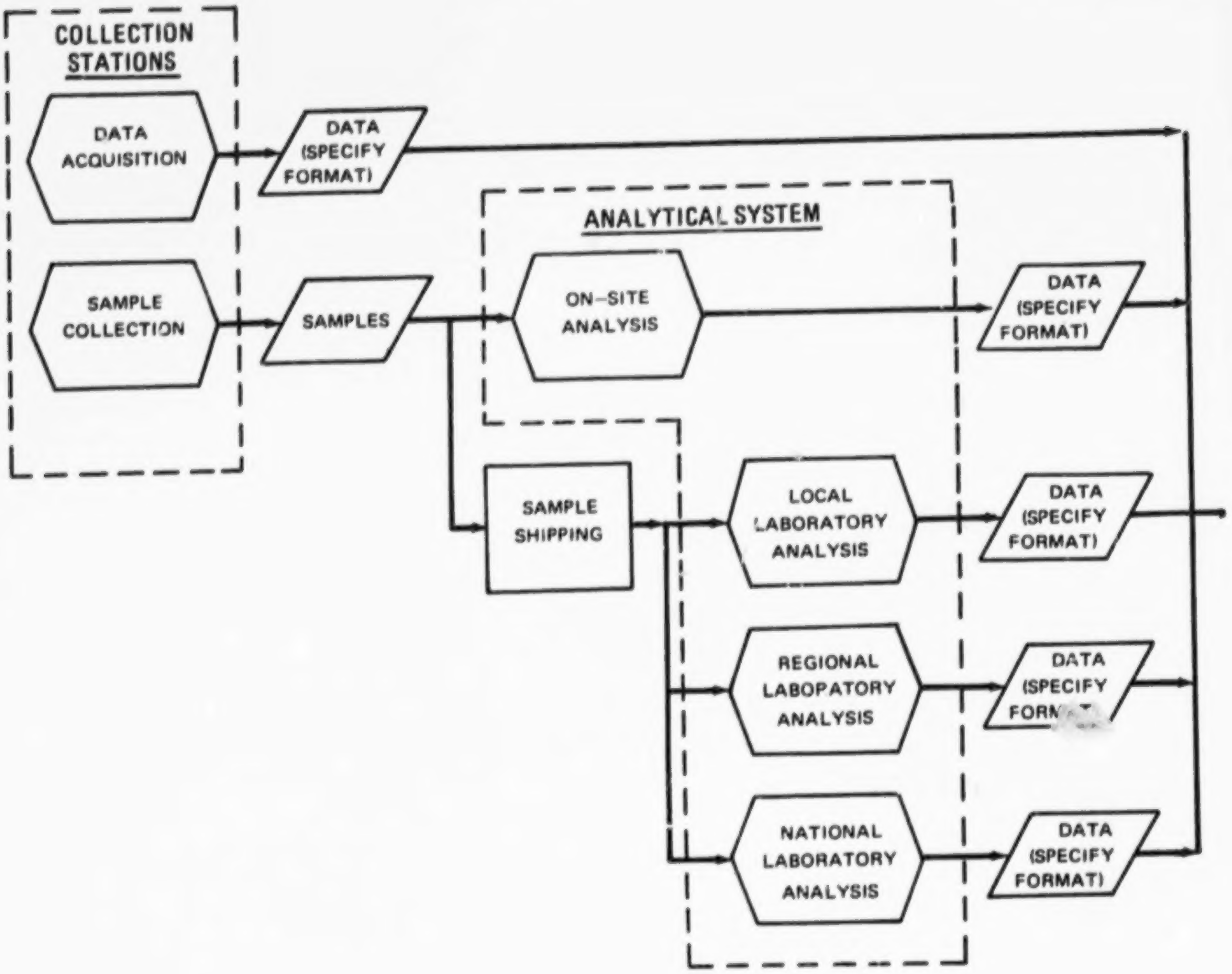
Activity 1

Identify and classify the bodies of water in each basin

Identify the bodies of waters (see categories 1., 2., and 3. in the Indexing Guide)

Classify the bodies of water or portions of the bodies of water into the following categories:

- Estuaries
- Impoundments


COLLECTION STATIONS
DATA ACQUISITION
DATA (SPECIFY FORMAT)
SAMPLE COLLECTION
SAMPLES
ANALYTICAL SYSTEM
ON-SITE ANALYSIS
DATA (SPECIFY FORMAT)
SAMPLE SHIPPING
LOCAL LABORATORY ANALYSIS
DATA (SPECIFY FORMAT)
REGIONAL LABORATORY ANALYSIS
DATA (SPECIFY FORMAT)
NATIONAL LABORATORY ANALYSIS
DATA (SPECIFY FORMAT)

DATA F

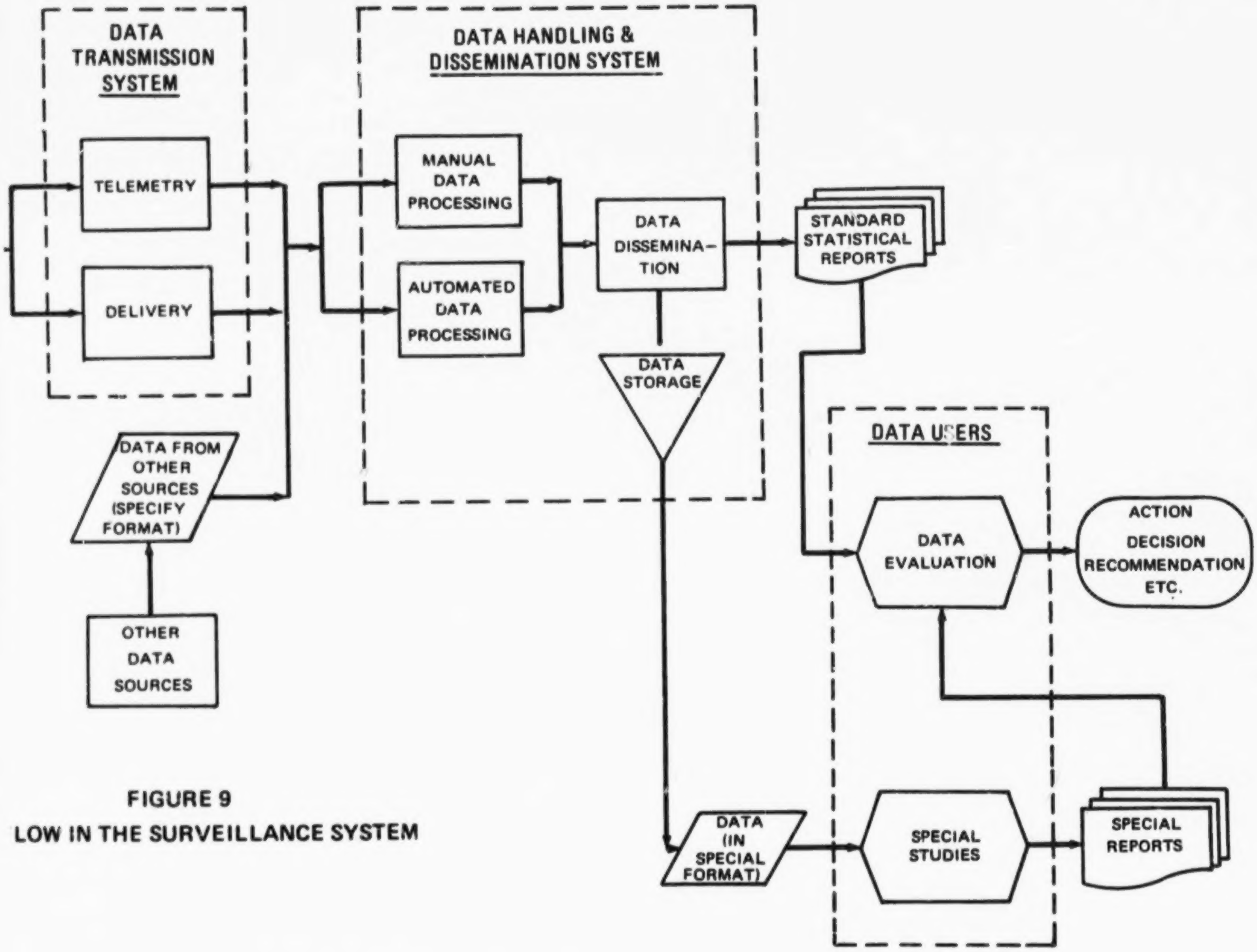

DATA TRANSMISSION SYSTEM
TELEMETRY
DELIVERY
DATA FROM OTHER SOURCES (SPECIFY FORMAT)
OTHER DATA SOURCES
DATA HANDLING & DISSEMINATION SYSTEM
MANUAL DATA PROCESSING
AUTOMATED DATA PROCESSING
DATA DISSEMINATION
DATA STORAGE
STANDARD STATISTICAL REPORTS
DATA USERS
DATA EVALUATION
ACTION DECISION RECOMMENDATION ETC.
DATA (IN SPECIAL FORMAT)
SPECIAL STUDIES
SPECIAL REPORTS

FIGURE 9
LOW IN THE SURVEILLANCE SYSTEM

- Lakes
- Reservoirs
- Saltwater intrusions
- Streams

(See Category 15 of the Indexing Guide)

Activity 2

Give an overall description of each basin under study. This description should indicate the particular types of water problems to be found in the basin and should also allow classification of the basin so as to facilitate comparison with other basins in future studies. The description should include information on characteristics such as:

- Population
- Climate
- Industry composition
- Agriculture
- Mineral production
- Power production
- Forests and recreational areas
- Economic parameters

(See Categories 10, 15 and 16 of the Indexing Guide)

Activity 3

Identify and quantify water quality and environmental parameters which are pertinent for specific areas of each basin.

BLANK PAGE

Identify the water quality and environmental parameters which are pertinent. These parameters should fall into the following four categories:

- Water quality biological parameters (See Category 8. in the Indexing Guide for list of these parameters)
- Water quality chemical parameters (See Category 9. in the Indexing Guide for list of these parameters)
- Water quality physical measurements (See Category 10. in the Indexing Guide for list of these parameters)
- Meteorological measurements (See Category 10. in the Indexing Guide for list of these parameters)

Quantify the parameters that have been identified for each basin. This quantification should include the average, variation, extremes, and any other statistics which are needed to describe the present values of the parameters.

Activity 4

Identify and quantify additional descriptive factors for specific areas of each basin. These factors should include the following:

Locations of state and other political boundaries

Information on municipalities

- Locations and size
- Source of potable water supply and rate of usage
- Sewage treatment facilities and the amount (rate) and quality of treated water put into streams

Neighboring soil characteristics

Information on water uses which are either affected by or affect the quality of water that they use

- Types of water uses: these types of usage should fall into the following categories

  - Agriculture (e.g., irrigation)
  - Industrial water supply (e.g., cooling water for nuclear power plant)
  - Potable water supply
  - Commercial fishing (indicate the species of fish)
  - Sport fishing (indicate the species of fish)
  - Commercial navigation
  - Pleasure boating
  - Body-contact sports
  - Esthetic
  - Other
- Location of these uses
- Does the use affect water quality or is it affected by the water quality (or both)
- Water quality parameters critical to each use or which are affected by the use
- Critical value of each parameter critical to each use
- Volume rate of use where applicable
- Other quantitative factors which describe the amount of use (e.g., number of sport fishermen)

Information on land uses which affect the runoff water conditions

- Types of and uses (e.g., mining and stock feedlots)
- Location of these uses
- Size of these uses
- Water quality parameters affected by these uses
- Pollution threat from these uses

Information on water controls

- Types of water controls (e.g., flood control dams, hydro-power dams, navigation dams, dredging operations, levies, dikes and breakwaters)
- Location of these water controls
- Size of these water controls
- Effects on water conditions

Information of pollution abatement facilities

- Types of abatement facilities
- Location of these facilities
- Size of these facilities
- Effect on water quality of these abatement operations

(See Categories 4, 15 and 16 in the Indexing Guide)

Activity 5

Acquire information on the water quality standards and plans of implementation and enforcement for each of the basins.

Review documented information on FWPCA, state, and local water quality standards and plans

Acquire supplemental information on standards and plans through interviews and site inspections in the basins

(See Category 11 in the Indexing Guide)

Activity 6

Identify and quantify water quality standards for specific areas of each basin

Identify the parameters for which standards are set

Identify the type or level of each standard as follows:

- Interstate
- Intrastate
- Local
- Compact
- Other

Identify the status of each standard as follows:

- Approved
- Tentative
- Recommended (specify who recommended it)
- Other

Identify the quantitative value of each standard

(See Category 11 in the Indexing Guide)

Activity 7

Identify and quantify present problematical conditions and sources

Identify the types of potential pollution (i.e., the water quality parameters whose values are in danger of exceeding limits of standards)

Identify the locations of potential pollution sources

- Difference between actual values and standards
- Conditions or changes in basin characteristics that can cause adverse changes in water quality parameters
- Probabilities of occurrence of these conditions

(See Category 13 in the Indexing Guide)

Activity 8

Identify and quantify projected future changes in the descriptive factors for the specific areas of each basin.

For all the descriptive factors that were covered in Activity 4 project future changes.. (For example, this might include the location and quantitative factors which will obtain condenser-cooling water from a river or it might include the quantification of the increasing volume rate of treated sewage water dumped into a steam by a rapidly growing city.)

Develop a chronological schedule of the projected future changes in the descriptive factors

(See Categories 13, 15, and 16 in the Indexing Guide)

Activity 9

Estimate the changes in the quantitative values of the water quality parameters as a result of the projected changes in the descriptive factors.

These estimates should include the average, variation, extremes and any other statistics which are needed to describe the future water conditions.

A chronological schedule of the estimated changes in the water quality parameters should be developed from the projected schedule of changes in the descriptive factors.

Activity 10

Identify and quantify potential future pollution problems and sources

Identify the types of potential future pollution (i.e., the water quality parameters whose values are in danger of exceeding the limits of standards)

Identify the locations of potential future pollution sources

Quantify the threat of potential future pollution

- Difference between estimated values and standards
- Conditions or changes in basin characteristics that can cause adverse changes in water quality parameters
- Probabilities of occurrence of these conditions

Develop a chronological schedule of the projected future pollution problems.

Activity 11

Identify the data users and their needs.

Identify the data users (list of agencies and their organizational units which will use data)

Identify the data needs of the user agencies (the purposes for which data is needed)

(See Categories 11 and 12 in the Indexing Guide)

Activity 12

Identify the intended use of the data and the types and quantity of data that should thus be collected to accommodate this use. Included within this activity will be a quantification of the measurement frequency required to achieve statistically significant conclusions.

Define the objectives of the surveillance system.

The general objectives of the surveillance system at any point in time should include at least the following:

- Detect and measure critical changes in the character of the water; (a time factor might also be included here, e.g., time to detect after pollution occurs)
- Determine the source of any pollution
- Establish base conditions from which to measure future change so that one can:

- Learn the actual value of proposed future pollution-control measures

- Be able to detect and measure changes in the future

(See Categories 11, 12 and 16 in the Indexing Guide)

Activity 14

Identify or formulate water quality criteria for specific areas of each basin. These criteria should include cause-effect relationships for each parameter, the specific parameters to be measured, measurement frequency requirements, acceptable techniques for measuring each parameter, and any other information pertinent to a description of the water quality conditions.

Activity 15

Catalog stretches of water according to the likelihood of need by measurement of relationship to water uses. In sequence, the steps to the accomplishment of this task are as follows:

- Identify and classify the bodies of water for the basin(s) under analysis

- Identify and quantify the water quality and environmental parameters pertinent to the geographical area of interest

    - Biological parameters
    - Chemical parameters
    - Meteorological parameters
    - Physical parameters

- Identify additional parameters which need to be measured in the future for each stretch of water on the basis of identifiable future uses. Additional consideration should be given to the measurement of currently unmonitorable parameters.

  Attach a chronological schedule as to when the future measurements will be needed

- Identify and scope the variations to be expected in terms of the water quality and environmental parameters identified

- Identify and quantify other factors descriptive of the basin(s) under study and pertinent to the establishment of water quality requirements

  - Types, locations and quantities of water uses

    - Agriculture
    - Sports
    - Esthetics
    - Fishing
    - Industrial water supply
    - Potable water supply
  - Political boundaries
  - Location and quantification of any existing pollution abatement facilities
  - Type, location and size of land use which affect runoff conditions
  - Types, locations and extent of water controls and stream channel maintenance

    - Dams
    - Navigation
    - Dredging
    - Discharge controls
  - Others

Of those factors previously listed, identify those affected by or contributing to the biological, chemical, physical, or meteorological environment. These conditions may currently exist or represent a potential problematical condition.

- Rank the water uses threatened by existing or projected water quality conditions, recognizing the related values placed on a specific use

Identify the applicable FWPCA, state and local water quality standards.

For the water quality and environmental parameter selected, determine the standard values. Consider potential changes to these levels.

Formulate a water quality criteria which addresses those constituents with the greatest impact on water use within the geographical area under study.

With an established water criteria which addresses significant water uses within the geographical area under study, determine sample measurement requirements to monitor compliance.

Consider near term and projected water uses and constituent pollutants on the basis as such considerations as:

- The population affected
- To what extent will a water use be impaired by a water quality change
- The economic consequences of water use impairment
- The utility of data for enforcement purposes
- The utility of data for long term prediction purposes
- The utility of data for evaluation of legislative actions

Activity 16

Identify the various surveillance agencies and identify and quantify the existing and planned sampling activities of each agency.

Identify the surveillance agencies (see category 12. in the Indexing Guide for a list of agencies)

Identify the existing sampling stations of each agency

Identify the planned sampling stations of each agency and the expected dates when they will become operational

Identify the parameters that are measured at each station

Identify the sampling techniques and equipment that are used at each station

Quantify the intensity of sampling at each station as to:

- Frequency in time
- Quantity of data

(See categories 5 and 12 of the Indexing Guide)

Activity 17

Identify additional data sources and the data that is available from these sources.

Identify additional sources of data

Identify the type of data available from these sources

Identify the quantity of each type of data that is available

Activity 18

Specify the desirable number and approximate locations of sampling stations along with the parameters to be measured at each station for near-term water quality monitoring

Specify the number and approximate locations of sampling stations which are needed at the present time. (The term approximate location refers to the specification of a stretch of water within which sampling would allow the detection and measurement of change and the determination of the source of such change.)

Identify the parameters to be measured at each station

Activity 18A

Resources availability with respect to time (near-term, future)

Are resources (funds, personnel, etc.) for total program currently available

If not, what portion of the total resources are currently available

Establish future resource requirements and prepare future budgetary requests

Activity 18B

Review legal status of methods

Review status of sampling methods and analytical techniques, etc., with respect to legal precedents

Consider possible test court cases

Activity 19

Specify the additional types of data to be collected at the near-term sampling stations for the purpose of establishing base conditions from which to measure future changes in water quality

Identify the additional parameters to be measured at each station for this purpose

Develop a schedule of when the measurement of these parameters should begin, and the frequency with which they should be measured, and the data volumes necessary to assure statistically accurate conclusions.

Activity 20

Specify the desirable number and approximate locations of additional future sampling stations along with the parameters to be measured and the schedule of when the stations are needed for future water quality monitoring.

Specify the number and approximate locations of additional sampling stations needed in the future. (Approximate location refers to the specification of a stretch of water within which sampling would allow the detection and measurement of change and the determination of the source of such change.)

Identify the parameters to be measured at each station

Develop a schedule of when these future stations will be needed

Activity 21

Specify any differences among more specific alternative sites (within the approximate location for each station) with respect to:

Design and performance characteristics (characteristics related to the collection system are included under System Design and Performance Characteristics in Check List)

Operating plans

- Intended activities
- Interfaces with activities of other subsystems
- Intended utilization rates

Threat (environmental and vandalism) and security factors (these factors are included under Threat Concept in Check List)

Accessibility

- Time requires to reach sampling stations
- Vehicles required in reaching the sampling stations
- Environmental conditions under which the stations cannot be reached

Legal considerations (See section on legal aspects for specific considerations)

Availability of existing sampling station

Availability of other existing facilities or structures that might be utilized

Availability of other facilities/structures, distinguishing between bridges, intakes, etc.

Activity 22

Resource Analysis

Identify differences in resource requirements and factors among more specific alternative sites (within the approximate location for each station) for each of the following resource categories:

- Sampling equipment
- Specialized support equipment (e.q., aircraft and watercraft)
- Facilities (see the Facilities Survey category in Check List)
- Personnel (number, skill mix, experience level, and training requirements)
- Logistic support (see the Logistic Support Concept category in Check List)

Order of magnitude estimates of the total resources required for the collection system may also be needed (e.q., to determine if the total resources required are within the constraints of available resources)

(See Category 5 in the Indexing Guide)

Activity 23

Effectiveness Analysis

Compute differences in the measures of effectiveness among more specific alternative sites (within the approximate location for each station). (See the System Effectiveness category in Check List)

Combine the various measures of effectiveness for each alternative into a single measure of effectiveness for the alternative. (The techniques for combining the various measures can include the use of mathematical expressions of laws of a discipline and also judgmental weighing factors.)

Order of magnitude estimates of the various measures of effectiveness may be required to determine if they are within acceptable limits.

Activity 24

Life Cycle Cost Analysis

Estimate differences in life cycle costs among more specific alternative sites (within the approximate location for each station). Estimates should be included for all differences identified in costs in all of the following categories:

- Development and test costs
- Acquisition costs
- Other investment costs
- Annual operations and support costs

Order of magnitude estimates of total costs in each of the above categories and a schedule of when dollars are needed may also be required to determine if the costs are within available funding resources.

Activity 24A

Cost Data

Assemble cost data for

- Equipment
- Personnel
- Operations

Consider projected cost increases and effect on planning needs

Activity 25

Cost-Effectiveness Analysis

Make comparisons between the more specific sites (within the approximate location for each station) on the basis of both life cycle cost and effectiveness. The basic idea is to determine the additional cost required for incremental improvements in effectiveness.

Activity 26

Analysis of additional considerations to select more specific locations (within the approximate location for each station) for the future sampling stations.

> Iteration of activities analygous to 21-25 so as to select the more specific locations for each of the project future sampling stations.

Data Flow in Surveillance Programs

A second major series of separable considerations in the design of a surveillance program relates to the flow of data from the surveillance stations. These considerations are shown in the diagram of Figure 9, and may be grouped in the following manner:

Collection stations are divided into two general categories. The usual mode is for the collection of water samples whereas an alternant is the utilization of data from other sources either public or private which will complement the system. This is particularly true in areas where surveillance data is sparse. Historical data acquisition has merit for projecting long term trends. Data of this type should be sought after and utilized where at all practical. Often format changes are necessary to use such data.

Analytical system data flow is critical at each step. The accuracy and precision of measurements if of extreme importance. The use of standardized methods of analysis and quality assurancy is mandatory. The use of significant data units begin here as does the use of uniform statistical techniques. The proper identity of the analytical data and the checks to assure the accuracy are repeated at each level.

Decisions on the flow of data relates to a need-to-know in certain instances, whereas a familarity with the usual results and patterns is of great value. The quality of data assurance is most effective at the local level and more difficult at each succeeding broader level. The use of common formats is encouraged.

Data transmission priorities have to be established. The considerations are of the critical need of the data in a proper time frame, and the ability of various transmission systems to accomplish the task with full knowledge of the true cost and time involved. The quality assurance of various transmission systems has to be evaluated. The ability to have feedback checks of the data is of value.

Data handling and dissemination systems are the final step in placing data into the proper need-to-know categories. The ability to react to critical water quality threats from spills and acts of nature are of the highest priority. The ability to compare the data with standards, to provide data of the quality necessary for enforcement, for the use of legislative bodies, for the use of planners, for the evaluation of projects, for long term planning goals all have an individual weight. The systems as developed have to transmit the data to the proper users in a reasonable time frame.

The numbers and types of data users continue to grow in proportion to the critical needs for water of quality in respect to the population and economic growth of the nation. The formats should be of such a nature that data can be extracted for a variety of broad or specialized uses. The weight of various users' needs in respect to a time framework is a combined need/economic value decision.

Frequency of Measurement

The frequency of measurement required to monitor and assure statistically viable conclusions with respect to water quality surveillance is considered by this project team to be of significant importance.

The solidification of a frequency of measurement requirement involves an interrelated consideration of; the water uses in their relative criticality; the water quality and environmental parameters; federal, state, and local standards; data requirements; sample acquisition techniques and others.

Figure 10 delineates the sequential steps appropriate to the determination of a frequency of measurement requirement. It is presented in general terms such that it may be implemented for any river basin. It remains for the analyst to tailor the procedure to fit the specific circumstance existing within the river basin under study. A review of the items listed in Activity [illegible]. will aid in the tailoring needed at each monitoring site.

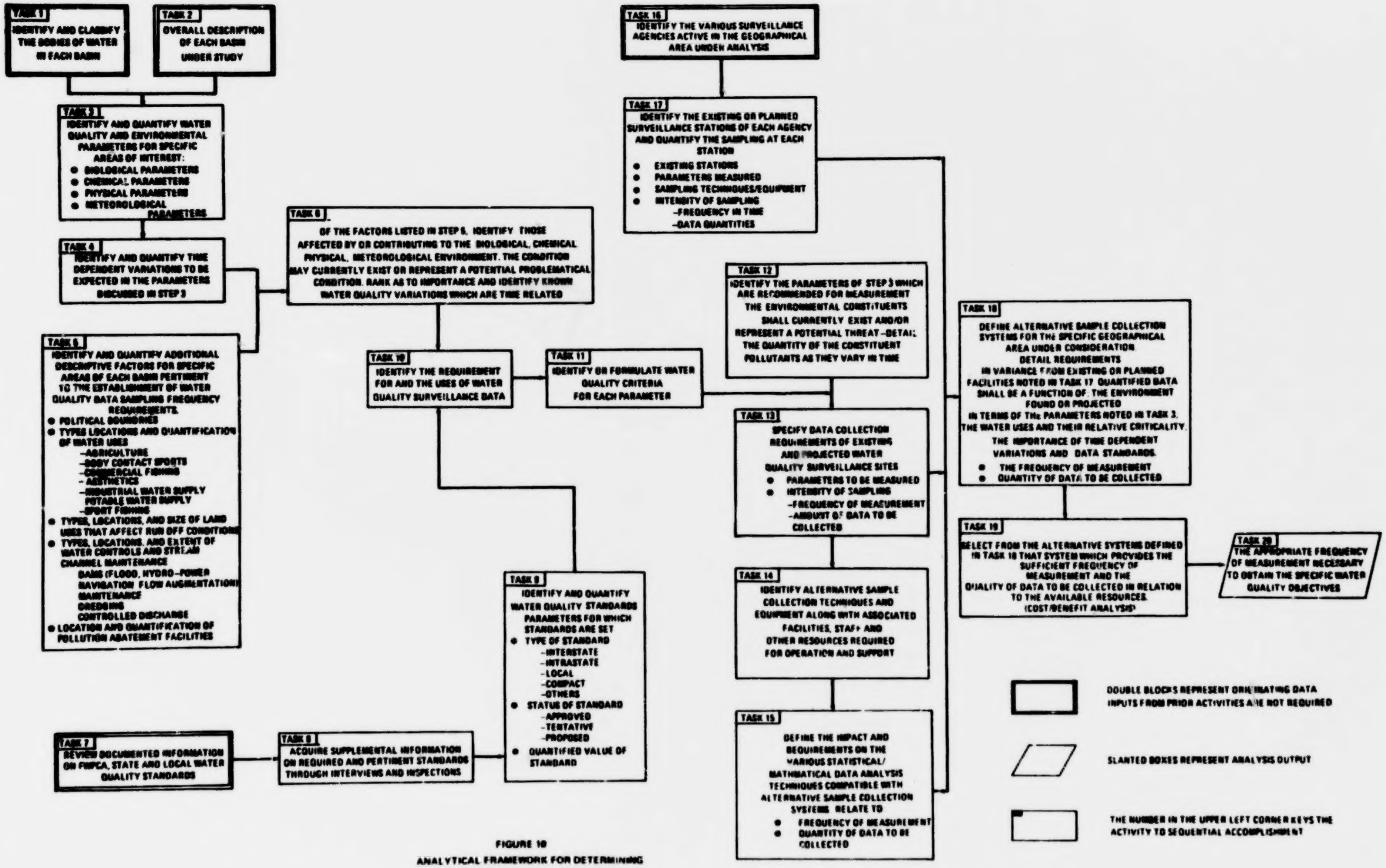

TASK 1 IDENTIFY AND CLASSIFY THE BODIES OF WATER IN EACH BASIN
TASK 2 OVERALL DESCRIPTION OF EACH BASIN UNDER STUDY
TASK 3 IDENTIFY AND QUANTIFY WATER QUALITY AND ENVIRONMENTAL PARAMETERS FOR SPECIFIC AREAS OF INTEREST:
● BIOLOGICAL PARAMETERS
● CHEMICAL PARAMETERS
● PHYSICAL PARAMETERS
● METEOROLOGICAL PARAMETERS
TASK 4 IDENTIFY AND QUANTIFY TIME DEPENDENT VARIATIONS TO BE EXPECTED IN THE PARAMETERS DISCUSSED IN STEP 3
TASK 5 IDENTIFY AND QUANTIFY ADDITIONAL DESCRIPTIVE FACTORS FOR SPECIFIC AREAS OF EACH BASIN PERTINENT TO THE ESTABLISHMENT OF WATER QUALITY DATA SAMPLING FREQUENCY REQUIREMENTS.
● POLITICAL BOUNDRIES
● TYPES LOCATIONS AND QUANTIFICATION OF WATER USES
-AGRICULTURE
-BODY CONTACT SPORTS
-COMMERCIAL FISHING
- AESTHETICS
-INDUSTRIAL WATER SUPPLY
POTABLE WATER SUPPLY
-SPORT FISHING
● TYPES, LOCATIONS, AND SIZE OF LAND USES THAT AFFECT RUN OFF CONDITIONS
● TYPES, LOCATIONS, AND EXTENT OF WATER CONTROLS AND STREAM CHANNEL MAINTENANCE
DAMS (FLOOD, HYDRO-POWER NAVIGATION FLOW AUGMENTATION)
MAINTENANCE
DREDGING
CONTROLLED DISCHARGE
● LOCATION AND QUANTIFICATION OF POLLUTION ABATEMENT FACILITIES
TASK 6 OF THE FACTORS LISTED IN STEP 5, IDENTIFY THOSE AFFECTED BY OR CONTRIBUTING TO THE BIOLOGICAL, CHEMICAL PHYSICAL, METEOROLOGICAL ENVIRONMENT. THE CONDITION MAY CURRENTLY EXIST OR REPRESENT A POTENTIAL PROBLEMATICAL CONDITION. RANK AS TO IMPORTANCE AND IDENTIFY KNOWN WATER QUALITY VARIATIONS WHICH ARE TIME RELATED
TASK 7 REVIEW DOCUMENTED INFORMATION ON FWPCA, STATE AND LOCAL WATER QUALITY STANDARDS
TASK 8 ACQUIRE SUPPLEMENTAL INFORMATION ON REQUIRED AND PERTINENT STANDARDS THROUGH INTERVIEWS AND INSPECTIONS
TASK 9 IDENTIFY AND QUANTIFY WATER QUALITY STANDARDS PARAMETERS FOR WHICH STANDARDS ARE SET
● TYPE OF STANDARD
-INTERSTATE
-INTRASTATE
-LOCAL
-COMPACT
-OTHERS
● STATUS OF STANDARD
-APPROVED
-TENTATIVE
-PROPOSED
● QUANTIFIED VALUE OF STANDARD
TASK 10 IDENTIFY THE REQUIREMENT FOR AND THE USES OF WATER QUALITY SURVEILLANCE DATA
TASK 11 IDENTIFY OR FORMULATE WATER QUALITY CRITERIA FOR EACH PARAMETER
TASK 12 IDENTIFY THE PARAMETERS OF STEP 3 WHICH ARE RECOMMENDED FOR MEASUREMENT THE ENVIRONMENTAL CONSTITUENTS SHALL CURRENTLY EXIST AND/OR REPRESENT A POTENTIAL THREAT -DETAIL THE QUANTITY OF THE CONSTITUENT POLLUTANTS AS THEY VARY IN TIME
TASK 13 SPECIFY DATA COLLECTION REQUIREMENTS OF EXISTING AND PROJECTED WATER QUALITY SURVEILLANCE SITES
● PARAMETERS TO BE MEASURED
● INTENSITY OF SAMPLING
-FREQUENCY OF MEASUREMENT
-AMOUNT OF DATA TO BE COLLECTED
TASK 14 IDENTIFY ALTERNATIVE SAMPLE COLLECTION TECHNIQUES AND EQUIPMENT ALONG WITH ASSOCIATED FACILITIES, STAFF AND OTHER RESOURCES REQUIRED FOR OPERATION AND SUPPORT
TASK 15 DEFINE THE IMPACT AND REQUIREMENTS ON THE VARIOUS STATISTICAL/ MATHMATICAL DATA ANALYSIS TECHNIQUES COMPATIBLE WITH ALTERNATIVE SAMPLE COLLECTION SYSTEMS RELATE TO
● FREQUENCY OF MEASUREMENT
● QUANTITY OF DATA TO BE COLLECTED
TASK 16 IDENTIFY THE VARIOUS SURVEILLANCE AGENCIES ACTIVE IN THE GEOGRAPHICAL AREA UNDER ANALYSIS
TASK 17 IDENTIFY THE EXISTING OR PLANNED SURVEILLANCE STATIONS OF EACH AGENCY AND QUANTIFY THE SAMPLING AT EACH STATION
● EXISTING STATIONS
● PARAMETERS MEASURED
● SAMPLING TECHNIQUES/EQUIPMENT
● INTENSITY OF SAMPLING
-FREQUENCY IN TIME
-DATA QUANTITIES
TASK 18 DEFINE ALTERNATIVE SAMPLE COLLECTION SYSTEMS FOR THE SPECIFIC GEOGRAPHICAL AREA UNDER CONSIDERATION. DETAIL REQUIREMENTS IN VARIANCE FROM EXISTING OR PLANNED FACILITIES NOTED IN TASK 17 QUANTIFIED DATA SHALL BE A FUNCTION OF: THE ENVIRONMENT FOUND OR PROJECTED IN TERMS OF THE PARAMETERS NOTED IN TASK 3. THE WATER USES AND THEIR RELATIVE CRITICALITY. THE IMPORTANCE OF TIME DEPENDENT VARIATIONS AND DATA STANDARDS.
● THE FREQUENCY OF MEASUREMENT
● QUANTITY OF DATA TO BE COLLECTED
TASK 19 SELECT FROM THE ALTERNATIVE SYSTEMS DEFINED IN TASK 18 THAT SYSTEM WHICH PROVIDES THE SUFFICIENT FREQUENCY OF MEASUREMENT AND THE QUALITY OF DATA TO BE COLLECTED IN RELATION TO THE AVAILABLE RESOURCES. (COST/BENEFIT ANALYSIS)
TASK 20 THE APPROPRIATE FREQUENCY OF MEASUREMENT NECESSARY TO OBTAIN THE SPECIFIC WATER QUALITY OBJECTIVES
DOUBLE BLOCKS REPRESENT ORIGINATING DATA INPUTS FROM PRIOR ACTIVITIES ARE NOT REQUIRED
SLANTED BOXES REPRESENT ANALYSIS OUTPUT
THE NUMBER IN THE UPPER LEFT CORNER KEYS THE ACTIVITY TO SEQUENTIAL ACCOMPLISHMENT

FIGURE 10
ANALYTICAL FRAMEWORK FOR DETERMINING THE FREQUENCY OF MEASUREMENT

The sampling frequency necessary to quantitatively define the quality dynamics in a body of water is related to periods of cyclic occurrences which control quality and to random influences. The latter are, for the most part, associated with meteorologic, manufacturing, and hydrologic events.

The tailoring procedure with respect to the generalized framework presented in Figure 10 involves the consideration of numerous time-dependent factors which are a function of:

- Type of water body in question
- The constituent wastes present
- The specific parameters of interest
- The major water uses

The number of samples required for a given river basin to fully define water quality involves a variability of parameters in the final analysis. Statistically speaking, foreknowledge of the variability of the parameters to be sampled and the precision desired must be understood. Intensive field studies may be necessary.

Samples collected must define the resultant water quality caused by influencing factors at a specific level of significance. Influencing factors include; the pollutant loads, manipulation of stream flow, sunlight, and others.

SECTION 6

SURVEILLANCE PROGRAMS DESIGN

The design of a surveillance program must take into account general considerations relating to the program objectives, the constraints imposed by resources and information availability, and the sensitivities of various factors which influence the choices between alternatives.

IMPLEMENTATION OF THE SYSTEMS APPROACH

The considerations to be taken into account in the design of a surveillance program may all be considered in an intuitive manner by an individual experienced with such programs. The systems approach simply insures that all elements will be considered in an orderly and efficient manner. Reference to Figure 7 reveals the vast amount of data that would be required for the optimum design of a surveillance program for a particular river basin. It is apparent that sophisticated means of data handling and machine computation would be required in order to make use of such an analytical framework. A narrative discussion of such a complicated system is not practical; one can, however, profitably consider a portion of this system as an example. Figure 8, which details the process of selecting surveillance station locations, can serve as a purpose. This portion of the complete analytical framework will be considered in discussing input information requirements and the sensitivities of design considerations.

Input Information Requirements

In Figure 8, input information is identified by the content of the double-lined blocks as follows:

Block No. 1 - Identification and classification of bodies of waters.

Block No. 2 - Overall description of the river basin(s).

Block No. 5 - Water quality standards and plans of implementation and enforcement.

Block No. 16 - Surveillance agencies; existing and planned activities.

Block No. 13 - Objectives of the surveillance system.

Block No. 11 - Data users and their needs.

Block No. 18A - Resources availability in the near and far terms.

Block No. 24A - Cost data.

Such information will typically be available in a wide variety of formats ranging from memos from data users voicing their needs, to the statistical data on water quality within the STORET system. The first step in implementing the systems approach is to acquire the pertinent mass of data available; the second step is to format this information in such a way that it is readily identifiable with the various other elements of the system and readily usable for analytical purposes.

To the extent that the volume of input information can be reduced, the analytical process is greatly aided. For example, if one can initially determine that surveillance stations will only be located near interstate boundaries for purposes of determining general compliance with the water quality standards, the volume of input data on the characteristics of the basin, historical water quality data, water uses, etc. can be greatly reduced from that available for the entire basin. Similarly, if available resources dictate that only a limited number of stations can be specified, the input data can be further reduced to consider only major interstate stream locations or those known to be particularly sensitive due to pollution incidents, extensive recreational uses, population density, etc.

The format of input information will vary widely depending upon the available data and the purposes of the surveillance program. The data format should seek to present information in as concise a manner as possible consistent with the objectives of the program. Water quality data, for example, should be available as yearly means, maxima, and minima for a parameter at a particular location if such information is sufficient for the purpose, rather than as lists of daily figures for several years; water quality standards should briefly list the critical parameters, keyed to specific locations. For iteration of analytical steps necessary to select among a few initially chosen locations or to determine specific parameters or sampling frequencies, more detailed data may be needed than was used in the initial analyses.

Sensitivities of Design Considerations

Figure 8 indicates no differences in the relative importance of the various considerations in the selection of station locations. This, of course, in a practical case is of utmost concern. These sensitivities will vary from one problem to another, but some general observations can be made. It is most likely that a surveillance program will be primarily limited by available resources, particularly funds for equipment and operation. In other cases, the needs of data users may be such that surveillance stations are to be established without regard to the cost entailed; this may be particularly true when a legal obligation dictates the need for data. The water quality standards may specify conditions beyond the capabilities of available monitoring instruments and this may impose a primary limitation, as may other technological considerations.

In some instances, sampling stations might be required immediately with little time available for specification and selection on the basis of a comprehensive analysis of the situation. Input information may not be available in some cases to implement a systems analysis framework. Available analytical time or lack of input information could well impose the primary constraints on the design of a program.

Specification of the relative importance or sensitivities of the various design considerations must be a matter of concern early in the analytical process and made an integral part of the analysis. Such sensitivities will vary from one case to another and are, to a large extent, matters of judgment on the part of the analyst.

Criteria for the Selection of Water Quality Surveillance Stations

It should be pointed out that water quality surveillance station locations were selected only for those streams specified for study in this project. These selections should not be construed as a sophisticated implementation of the systems analysis framework.

The following water quality surveillance stations have been selected as the most immediate needs of those streams studied. The techniques outlined in the Systems Analysis

Framework have been utilized manually to assemble all of the information and data necessary to decide the priorities for immediate implementation. A particular ranking system has been utilized which, although simple, still encompasses the needs and priorities. It is concluded that the first rank selections should enable the FWPCA to evaluate compliance with the Interstate Water Quality Standards particularly at the interstate borders. If these Interstate Water Quality Standards are being met at those locations, there will be less need for surveillance stations at other locations. That is, meeting the Interstate Water Quality Standards at the state borders will likely provide the promised performance sought. It is recognized that placing all of the water quality surveillance stations at the interstate borders does not provide protection from threats of pollution sources within a state's borders.

It is of prime importance that some water quality surveillance stations be placed in such a way as to protect those waters which are used for potable water sources. Here again, a rank can be applied since the populations served by various water companies are known. Therefore, strictly on a population basis, it is possible to compute a rank for the protection of the greatest number of persons. A major city would thus out-rank a smaller city in the need for protection for its source of potable water.

The third highest rank in the assignment of water quality surveillance stations would be to monitor major pollution sources. This is of particular value when the pollution source is not amenable to immediate treatment or when construction schedules are lagging. Additional surveillance of the situation may be necessary during an interim period before adequate treatment can be installed. Thus, highly polluted areas will need surveillance of the levels of pollution at its sources. This type of surveillance, when maintained properly, allows the proper authority adequate warning as to particularly bad situations and may indicate the need for action in order to protect downstream water users.

Additional ranking can also be provided for waters that are utilized for recreation such as body contact sports, hunting, and fishing; agriculture, both farmstead and irrigation; and the wide variety of industries.

Using the above ranking considerations, Class I Water Quality Surveillance Stations were assigned to locations on the basis of their relation to (1) Interstate borders, (2) Potable water supplies of major population centers, (3) Major pollution sources.

Class II Water Quality Surveillance Stations were assigned to locations such that they would monitor the quality of streams tributary to those considered in this project. These will include both interstate and intrastate streams.

Parameters and Frequency of Measurements

Rather than go through the procedure of listing for each proposed water quality monitoring site the parameters to be measured, the following procedure has been selected. First, the Class I water quality monitors should have continuous water quality monitors installed at the sites. The monitors should meet the current FWPCA specifications and should have telemetry capabilities. They should monitor the following parameters hourly: pH, dissolved oxygen, dissolved chlorides, conductivity, water temperature, and turbidity. Each of these monitors should have the ability to collect a composite water sample over a 24-hour period. The composite sampler should be actuated 24 hours before the routine maintenance visit. This composite sample should be collected semi-monthly. This composite sample should be analyzed at one of the state or regional laboratories.

Other than the six measurements previously mentioned, there are other measurements which should be accomplished on all samples. They should be analyzed semi-monthly for: plankton, radioactivity, total organic carbon, and pesticides. These data are necessary for long-term predictions in overall water quality. The balance of the measurements made at each of the Class I sampling stations should be determined for each location by referring to that section of the Appendix in which the standards for that site are listed.

At many sites, there is a common border between two states; or in other cases, the river may be the interstate border. The standards for all states applying to a particular point on the stream should be consulted. The standards are listed for each of the points where placement of water quality monitors have been suggested. In certain cases, one or more monitors may fall within one area. The analyses to be accomplished on each sample should be the total to satisfy all of the water quality standards for each of the states concerned at that sampling point. To have listed them for each point would be rather repetitious and was not done in order to conserve space.

For the Class II water quality monitoring sites, the analysis should be identical to the Class I stations with the exception of the continuous recording of the six parameters. However, these six should be analyzed for on the sample collected monthly. These monthly samples would be best collected by automatic composite samplers that are mounted permanently. They could be actuated one day and collected the next. If this is not feasible, they could be collected manually as a grab sample recognizing the limitations of such sampling. It will not be possible to analyze for carbon under these conditions using the carbon filter technique.

The general site selection for a water quality surveillance station can be accomplished by using the methods outlined in the systems analysis framework. However, the final site selection would need additional field measurements at various points within the selected area. The analysis of such chemical and physical measurements will allow the final selection of the site to be made. It may require that these measurements be repeated under a variety of flow conditions before sufficient data can be assembled for proper judgments.

Particular attention should be given to the two general approaches to site selection. One school of thought utilizes sites where large volumes of water are withdrawn such as potable or cooling water users. There are drawbacks from the effects of velocity and passage through cribs and the like. Others prefer sites which use submersible pumps at a single point in the stream. Here again, there are distinct advantages and disadvantages. The decision cannot be generalized and each site must be judged on its own merits.

Attention should be given to the historical flood data for the area to prevent damage to the equipment and to insure access to the site. In sites where stage height is variable, care should be given to the selection of the intake depth. In certain cases, a multi-depth intake with proper switching is recommended. Floating platforms have been used to alleviate this problem quite effectively.

The sampling frequencies specified were made on the basis of the needs to protect the various water uses considering the response time for specific pollutants for the Class I stations. The Class II station frequency was selected only to provide the necessary information for future evaluation.

Selection of Water Quality Surveillance Stations

Class I Water Quality Surveillance Stations for the Ohio River Basin and the Tennessee River Basin

They are listed by number which corresponds to a site number on Figure 12.

1. The Ohio River at Mounds City Lock and Dam.
2. The Tennessee River at the Kentucky-Tennessee State Line.
3. The Tennessee River at the Pickwick Landing Lock and Dam to monitor the Tennessee-Alabama-Mississippi State Line.
4. The Tennessee River at the Tennessee-Alabama State Line at Nickajack Dam, which also monitors wastes downstream of Chattanooga.
5. The Ohio River at the Indiana-Illinois-Kentucky State Line near the junction of the Wabash River.
6. The Wabash River near its mouth at the Ohio River; this is also between the Indiana-Illinois State Line.
7. The Wabash River near Terre Haute, Indiana at the Illinois-Indiana State Line.
8. On the Cheat River near the Pennsylvania-West Virginia State Line.
9. On the Ohio River upstream of Louisville, Kentucky to monitor the potable water intake.
10. On the Ohio River downstream of Cincinnati, Ohio at the Indiana-Ohio State Line and wastes from the city.
11. On the Ohio River upstream of Cincinnati, Ohio to monitor the potable water supply for Cincinnati.
12. On the Ohio River at the West Virginia-Kentucky-Ohio State Line near Ashland, Kentucky.
13. On the Kanawha River near its mouth at the Ohio River downstream of the industrial outfalls of Charleston, West Virginia at the Winfield Dam.

14. On the Ohio River near the Ohio-West Virginia-Pennsylvania State Line, possibly at the New Cumberland Dam or ORSANCO station at Stratton, Ohio.

15. On the Ohio River downstream of Pittsburgh, Pennsylvania at the Dashshields Lock and Dam to monitor Pittsburgh and the Allegheny and Monongahela Rivers.

16. On the Allegheny River at Oakmont, Pennsylvania, this would protect the potable water quality for Pittsburgh, Pennsylvania. ORSANCO currently has a station at this point which should be utilized.

17. On the Allegheny River at the Allegheny Reservoir Dam near the New York-Pennsylvania State Line.

19. On the Monongahela River near Pittsburgh, possibly at one of the ORSANCO stations.

20. On the Monongahela River at Morgantown Lock and Dam near the Pennsylvania-West Virginia State Line.

Class II Water Quality Surveillance lists for the Ohio and Tennessee River Basins

They are listed by number which corresponds to a site number on Figure 12.

18. Allegheny River at New York-Pennsylvania State Line at Portville, New York.

21. Mahoning Creek at its mouth near Mile Point 65 of the Allegheny River. There is a bridge and a dam in the vicinity.

22. Red Bank Creek near its mouth at Mile Point 64 of the Allegheny River. There is a bridge near the mouth.

23. On the Clarion River near its mouth on the Allegheny River.

25. French Creek near its mouth on the Allegheny River.

26. Oil Creek near its mouth on the Allegheny River.

27. Turtle Creek at its mouth as it enters the Monongahela River near Mile Point 11.

28. The Youghiogheny River near its mouth as it enters the Monongahela River at Mile Point 16.

29. The Tygart River near its mouth where it joins to form the Monongahela River.

30. The West Fork River near its mouth where it joins to form the Monongahela River.

31. The Kiskiminetas River near its mouth at the Allegheny River at Mile Point 30.

32. Crooked Creek near its mouth on the Allegheny River at Mile Point 40. The Crooked Creek Dam could be used as the site.

33. The Gauley River near its mouth where it joins to form the Kanawha River.

34. The New River near its mouth where it joins to form the Kanawha River.

35. The Cumberland River near its mouth where it joins the Ohio River.

36. The Saline River near its mouth where it joins the Ohio River.

37. The Tradewater River near its mouth where it joins the Ohio River.

38. The Green River near its mouth where it joins the Ohio River.

39. The Salt River near its mouth where it joins the Ohio River.

40. The Kentucky River near its mouth where it joins the Ohio River.

41. The Mill Creek near its mouth where it joins the Ohio River.

42. The Miami River near its mouth at the Ohio River.

43. The Licking River near its mouth where it joins the Ohio River.

44. The Little Miami River near its mouth where it joins the Ohio River.

45. The Scioto River near its mouth where it joins the Ohio River.

46. The Hocking River near its mouth where it joins the Ohio River.

47. Big Sandy River near its mouth at the Ohio River.

48. The Little Kanawha River near its mouth where it joins the Ohio River.

49. The Muskingum River near its mouth where it joins the Ohio River.

50. The Beaver River near its mouth where it joins the Ohio River.

51. The Duck River near its mouth where it joins the Tennessee River.

52. The Bear River near its mouth where it joins the Tennessee River.

53. The Elk River near its mouth where it joins the Tennessee River.

54. The Hiwassee River near its mouth where it joins the Tennessee River.

55. The Clinch River near its mouth where it joins the Tennessee River.

56. The Little Tennessee River near its mouth where it joins the Tennessee River.

57. The French Broad River where it joins to form the Tennessee River.

58. The Holston River near its mouth where it joins to form the Tennessee River.

59. The Tennessee River at the nearest bridge downstream of Knoxville, Tennessee.

Class I Water Quality Monitors for the Southeastern Basins

They are listed by a number which corresponds to a site number on Figure 13.

1. On the Escambia River below its confluence with the Conecuh River. Monitor Station No. 55035 is located here and should be upgraded.

5. At Pensacola Bay and U. S. Highway Bridge 98 for the Escambia-Pensacola Bay area.

9. The Choctawhatchee River at the Alabama-Florida State Line. There is an existing sample station 50015 in this vicinity.

12. The exit from the Choctawhatchee Bay there is a bridge across the bay exit across Santa Rosa Island. Locate the monitor with the intake near the channel entrance.

16. The Ochlockonee River south of the Florida-Georgia State Line on Highway Bridge No. 27.

20. U. S. Highway Bridge Route 98 as it crosses Ochlockonee Bay.

21. The Pascagoula River below the confluence of the Leaf River and Chickasawhay Rivers at highway No. 26 bridge. This is downstream of the Alabama-Mississippi State Line.

25. The east branch of the Pascagoula River on Highway Bridge U. S. 90.

26. The Mobile River below the junction of the Alabama and Tombigbee Rivers. There are no structures across the river in this zone. Most probably will have to have a submarine entrance, which is protected from shipping.

30. The Mobile River at U. S. Highway 90 and 98 bridge crossing near the City of Mobile.

36. The Tombigbee River at the Mississippi-Alabama border. There is an existing FWPCA station at this point, its number is 56660.

37. The Tombigbee River at the Demopolis Lock and Dam.

43. The Alabama River below Selma, Alabama.

49. The Pearl River at Highway Bridge Route 26 near Bougelousa, Louisiana. The Pearl is the common border between Louisiana-Mississippi. This is the first bridge south of the northern border of Louisiana and Mississippi.

50. The Pearl River at its entrance into Lake Borgne at the Louisville and Nashville railroad bridge. This is the entrance of the East or the main branch of the Pearl River into Lake Borgne and later to Mississippi Sound.

52. The Perdido River at bridge on Highway No. 31 at the Alabama-Florida border.

54. On Route 42 Highway bridge in Perdido Bay.

59. The Chattahoochee River at the Georgia-Alabama State Line at the West Point Dam.

61. The Chattahoochee River at the Alabama-Georgia-Florida State Line, Highway Bridge Route 2 and 91 of the State Line.

62. The Jim Woodruff Dam exit of Lake Seminole at the Georgia-Florida State Line at the junction of the Chattahoochee, the Flint, and Spring Creek to form the Apalachicola River.

63. The Apalachicola Bay at the John Gorrie Memorial Bridge on the left side near the intercoastal channel, near the City of Apalachicola.

Class II Water Quality Monitoring Stations in the Southeastern River Basins

They are listed by a number which corresponds to a site number on Figure 13.

2. The Escambia River at US-90A Highway Bridge near the entrance to Escambia Bay.

3. Pensacola Bay on a Highway Bridge crossing Bayou Chico.

4. The Blackwater River at U. S. Highway 90 Bridge near the entrance to Blackwater Bay.

7. The Yellow River at Highway Bridge on Route 2. Station No. 63840 should be upgraded.

8. The Yellow River near its mouth. At Highway No. 87 Bridge.

10. The Choctawhatchee River below the confluence with Wrights Creek at U. S. 90 Highway Bridge. Sampling Station No. 53278 should be upgraded.

11. The Choctawhatchee River below the confluence with Holmes Creek at Highway No. 20 Bridge. Sampling Station No. 61943 should be upgraded.

13. Ochlockonee River downstream of Moultrie.

14. Ochlockonee River at Highway Bridge Route No. 93 below Thomasville.

18. Ochlockonee River at Highway Bridge Route No. 267 below Lake Talquin.

24. Escatawpa River at Highway Bridge No. 63 before it enters the Pascagoula Bay.

28. Chickasaw Creek at its mouth on the Mobile River at a L&N Railroad Bridge.

29. Three Mile Creek at its mouth on the Mobile River at a L&N Railroad Bridge.

32. Highway Bridge Route No. 163 crossing Dog River at its mouth in Mobile Bay.

33. Tombigbee River south of Aberdeen, Mississippi.

34. Tombigbee River below the junction of the East and West Forks near Amory, Mississippi at Monitor Station No. 56838 which needs upgraded.

35. Tombigbee River below the entrance of Town Creek.

38. Tombigbee River below the confluence of Sucarnoochee Creek.

40. Tombigbee River at U. S. No. 43 Highway Bridge. Near Jackson.

44. Alabama River at U. S. No. 82 Highway Bridge downstream of Montgomery, Alabama at 54571 which needs upgraded.

45. Alabama River at the Claiborne Lock and Dam.

48. Pearl River at Route No. 15 Highway Bridge downstream of Bogue Chitto.

48. Pearl River at Route No. 28 Highway Bridge downstream of Jackson.

51. Rigolets at Route 90 Highway Bridge downstream of Lake Pontchartrain.

53. Eleven Mile Creek at Route 90 Highway Bridge before it enters Perdido Bay.

55. Conecuh River at Route No. 41 Highway Bridge near East Brewton. Before Alabama-Florida State Line.

57. Chatahoochee River at the Buford Dam.

58. Chatahoochee River at Route No. 20 Highway Bridge downstream of Atlanta.

60. Chatahoochee River at the Water F. George Lock and Dam.

64. Flint River at Route No. 37 Highway Bridge South of Albany.

65. Spring Creek at Route No. 82 Highway Bridge.

Class I Water Quality Monitoring Sites in the Lower Missouri River Basin

They are listed by number which corresponds to a site number on Figure 14.

1. On the Missouri River at St. Louis, Missouri. This is one of the old network stations. It monitors the effect of the Missouri River on the Mississippi River. It also monitors the potable water supply for St. Louis, Missouri. Data are being collected at two water plants of the city and county of St. Louis. These should be upgraded and the station centralized in one of the plants.

2. The Osage River at Osage City, Missouri near its mouth at the Mississippi River. There are several bridges to choose from for the final site. This station can monitor the effect of the Osage River on the Missouri River.

3. The Marais des Cygnes River near the Missouri-Kansas State Line.

4. The Missouri River at Missouri City, Missouri. This is an old network station which monitors the effect of pollution from Kansas City crossing interstate lines between Missouri and Kansas.

5. On the Missouri River at Kansas City, Kansas to monitor the potable water supply for Kansas City. This again, is an old network station.

6. The Kansas River at Kansas City or possibly at DeSoto, Kansas. The latter is an old network station to monitor the effect of the Kansas River watershed on the Missouri River.

7. The Smoky Hill River at Enterprise, Kansas near its mouth at the Kansas River. Here the USGS Station No. 50250 can be upgraded.

8. The Republican River at the Kansas-Nebraska border near Hardy, Nebraska. Both the States of Kansas and Nebraska have sampling stations here. They should be upgraded and combined into a single station.

9. On the South Fork of the Republican River near Benkelman, Nebraska. Here again, both Nebraska and Kansas have monthly stations which should be combined and upgraded.

10. The Missouri River at the Kansas-Nebraska-Missouri State Line. This site should be at the Bridge near Rulo, Nebraska. This bridge is eight miles upstream from the state line. This should replace the existing old network station at St. Joseph, Missouri which is 38 miles downstream from the state line.

11. The Missouri River at the Nebraska-Kansas-Iowa State Line. This site should be at a bridge near Nebraska City, Nebraska which is 10 miles upstream from the state line. This would monitor the effect of wastes from Omaha, Nebraska and mineral wastes from the Platte River.

12. The Platte River at Plattesmouth, Nebraska. This is an old network station located upstream of the mouth of the Platte before it joins the Missouri River. This should be upgraded.

13. The South Platte River at Julesburg, Colorado near the Colorado-Nebraska State Line. This is an old network station which should be upgraded.

14. On the South Platte River downstream of the City of Denver, Colorado to monitor local municipal and industrial wastes.

15. On the South Platte River at the municipal water intakes for the City of Denver. Although this is only a portion of the supply, it should be monitored since it is a potable supply for a large population.

16. On the North Platte River at Henry, Nebraska. This again is an old network station which should be upgraded.

17. The old network station at Yankton, South Dakota. This is located seven miles below Gavin's Point Dam at the municipal water treatment plant. This station should be upgraded.

In the Missouri Basin, it was observed that many interstate streams which when crossing interstate lines present no problems. For the most part, they are either of very good quality, or they are very small or intermittent streams. Therefore, even though standards may have been written, no surveillance at this time would be justified other than brief intermittent sampling. This is true of the Smoky Hill River and the South Fork of the Republican River as they pass from Kansas into Colorado. A similar situation occurs where the North Platte flows from Colorado into Wyoming and where the Niobrara flows from Wyoming into Nebraska.

Class II Water Quality Monitoring Sites for the Lower Missouri River Basin

They are listed by a number which corresponds to a site number on Figure 14.

18. The Niobrara River near its mouth as it enters the Missouri River near the Louis and Clark Lake upstream from Yankton and the Gavin's Point Dam. There is a railroad bridge and highway bridge which can serve as monitoring point locations.

19. On the North Platte River, additional monitoring points should be established just upstream of the mouth of the North Platte River near North Platte, Nebraska, to monitor the effect of the North Platte on the Platte River.

20. North Platte River downstream of the Casper, Wyoming to monitor oil processing plants. Although there were no apparent discharges, the housekeeping of these plants was such that pollution would occur during high water periods.

21. North Platte River at the Colorado-Wyoming border.

22. Niobrara River at Box Butte Reservoir. This is in the headwaters area of the Niobrara River and could serve to monitor these temporary streams which come from the general area and from across the state line in Wyoming.

23. The City of Denver maintains a water quality station at the Discharge of the Eleven Mile Canyon Reservoir near the headwaters of the South Platte River.

24. South Platte River downstream of the Arapahoe Power Plant and the municipal sewage disposal plant. There are several bridges to be selected from here. The sanitary discharge is especially inadequate. It definitely pollutes the stream and is somewhat stratified.

25. South Platte River near Sam Creek. Upstream of this point there are refineries and other waste treatment facilities.

26. South Platte River downstream of the City of Greeley, Colorado where the world's largest cattle feed areas are located. Waste treatment facilities are there but don't seem to be that adequate. The odor is so intense that it was very much in evidence in 2,000 feet above the cattle pens. There is a bridge at Route 37 which would be a suitable point.

27. Platte River at Brady, Nebraska. The USGS maintains a monitoring station No. 50369 which is downstream of the City of North Platte. This is a monthly sampling station which should be upgraded.

28. Loup River near its mouth on the Platte River. The State of Nebraska maintains water quality station No. 61596 on the diversion canal from the Loup River which should be upgraded to a monthly station and more parameters should be measured.

29. The Republican River at its mouth. There are several monitoring points maintained here already. There should be a culmination of the efforts into a good monthly station.

30. The mouth of the Little Osage River or possibly back at the Kansas-Missouri border before it joins the Marais des Cygnes River to form the Osage River.

31. The mouth of the Gasconade River as it enters the Missouri River. A possible site would be on a highway bridge for Route 100 which crosses near the mouth. There is also Missouri Pacific railroad bridge in the vicinity.

32. The Lamine River near its mouth at Mile Point 202 in the Missouri River. There are highway and railroad bridges in the vicinity.

33. The Chariton River near its mouth at Mile Point 239 on the Missouri River. There is a bridge about six miles back upstream that could serve as a monitoring point.

34. The Grand River near its mouth at Mile Point 250 on the Missouri River. There are two highway bridges near Brunswick, Missouri which can serve as monitoring points.

35. The Big Blue River near its mouth at Mile Point 358 on the Missouri River.

36. The Missouri River at a bridge near Mile Point 353. It carries Highway No. 71 to monitor industrial and municipal effluents upstream of this point.

37. The Floyd River near its mouth at River Mile 731. There are highway and railroad bridges in the vicinity.

38. The Big Sioux River near its mouth at Mile Point 734 on the Missouri River. There's a highway bridge in the vicinity.

SECTION 7

ACKNOWLEDGMENTS

The support of the Project Officer, Mr. William T. Sayers of the Pollution Surveillance Branch is acknowledged with sincere thanks. He was aided in his task by Mr. James H. McDermott, and Mr. Phillip L. Taylor of the Pollution Surveillance Branch, Operations Program, and by Dr. Roger D. Shull of the Pollution Control Analysis Branch, Research and Development Program, Federal Water Pollution Control Administration.

Additional aid and cooperation was provided by Messrs. Irwin L. Dickstein, Robert L. Markey, Dale B. Parke, Keith O. Schwab, and Lee B. Tebo, Jr., of the three Regional Offices of the Federal Water Pollution Control Administration which were studied.

The Project Manager was Mr. Paul V. Morgan, Cyrus Wm. Rice Division - NUS CORPORATION. He was aided by Mr. Brownie R. Johnson, Consultec, Inc.; Dr. Henry C. Bramer, Gurnham Bramer, and Associates, Inc.; and Mr. Wallace L. Duncan, Jennings, Strouss and Salmon. They, in turn, were supported by the staffs of the respective groups.

SECTION 8

REFERENCES

"Acid Mine Drainage Pollution Study - Chartiers Creek Watershed - Allegheny and Washington Counties - Phases 1 and 2," Prepared by *A. C. Ackenheil and Associates for the Pennsylvania Dept. of Mines and Mineral Industries*, (1968).

"Amendments to the Rules and Regulations," *Commonwealth of Pennsylvania Department of Public Health*, (1968).

"Appendix B to Municipal Waste Report," Metropolitan Denver Area, South Platte River Basin," *Public Health Service, U. S. Dept. of HEW*, (1965).

"Aquatic Life Criteria - First Progress Report," Ohio River Valley Water Sanitation Commission, *Sewage and Industrial Wastes*, (1955).

"Aquatic Life Resources of the Ohio River," *Ohio River Valley Water Sanitation Commission*, (1962).

"Aquatic Life Water Quality Criteria - Second Progress Report," Ohio River Valley Water Sanitation Commission, *Sewage & Industrial Wastes*, Vol. 28:5, pp. 678-90, (1955).

"Aquatic Life Water Quality Criteria - Third Progress Report," Ohio River Valley Water Sanitation Comm., *Journal Water Pollution Control Federation*, Vol. 32:1, (1960).

"Aquatic Life Water Quality Criteria - Fourth Progress Report," Ohio River Valley Water Sanitation Comm., *Environmental Science & Technology*, Vol. 1:11, (1967).

"Asiatic Clam (Corbicula)," Gruver, Merle., *American Iron and Steel Institute*, (1966).

"Bacterial - Quality Objectives for the Ohio River," *Ohio River Valley Water Sanitation Commission*, (1951).

"Barr Lake and Its Odor Relationships," *Public Health Service, U. S. Dept. of HEW*, (1965).

"The Beet Sugar Industry -- The Water Pollution Problem on Status of Waste Abatement and Treatment," *Federal Water Pollution Control Adm., U.S. Dept. of Interior*, (1967).

"Big Sioux River Drainage Basin: A Cooperative State-Federal Report on Water Pollution October, 1951, Water Pollution Series No. 21," *Public Health Service, Federal Security Agency*, (1951).

"1961 Budget," Joe G. Moore, Jr., *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1969).

"Catalog of Federal Pesticide Monitoring Activities in Effect July, 1967," Federal Committee on Pest Control, *Department of Agriculture, Department of Defense, Department of HEW, U. S. Dept. of the Interior,* (1968).

"Central Missouri River Drainage Basin. A Cooperative State-Federal Report on Water Pollution, June, 1952. Water Pollution Series No. 24," *Nebraska Department of Health, North Dakota Department of Health, South Dakota Department of Health, Wyoming Department of Health, Public Health Service, Federal Security Agency,* (1952).

"Certification of Administrative Rules Filed with the Secretary of State," *Florida Air & Water Pollution Control Commission,* (1969).

"Chemical Quality of Surface Water in the Allegheny River Basin, Pennsylvania and New York," E. F. McCarren, Water-Supply Paper 1835, *U. S. Geological Survey,* (1967).

"Chemical Quality of Surface Waters in Pennsylvania," C. N. Durfor and P. W. Anderson, Water-Supply Paper 1619, *U. S. Geological Survey,* (1963).

"Chemical Water Quality of the Lower Kansas River Basin," Walter J. O'Brien and Ernest E. Angino, Univ. of Kansas, *Federal Water Pollution Control Administration,* (1966).

"Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina," *Board of Water and Air Resources, Department of Water and Air Resources,* (1968).

"Chlorinated Hydrocarbon Pesticides in Major River Basins, 1957-65," A. W. Breidenbach, C. G. Gunnerson, F. K. Kawahara, J. J. Lichtenberg, R. S. Green, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1967).

"Chlorinated Hydrocarbon Pesticides in Major U. S. River Basins," Leo Weaver, G. Gunnerson, W. Breidenbach, and James J. Lichtenberg, *Public Health Service, U. S. Dept. of HEW,* (1965).

"Compendium of Department of the Interior Statements on Non-degradation of Interstate Waters," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968).

"A Comprehensive Program for Control of Water Pollution, Missouri Drainage Basin: A Cooperative State-Federal Report on Water Pollution, July, 1953. Water Pollution Series No. 56," *Public Health Service, U. S. Dept. of HEW,* (1953).

"Conference at St. Joseph, Missouri on Interstate Pollution in the Missouri River," *Public Health Service, U. S. Dept. of HEW,* (1957).

"Conference in the Matter of Pollution of the Interstate Waters of the Chattahoochee River and its Tributaries, from Atlanta, Georgia to Fort Gaines, Georgia," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1966).

"Conference in the Matter of Pollution of the Interstate Waters of the North Platte River, Third Session," *U. S. Dept. of HEW,* (1963).

"Conference in the Matter of Pollution of the South Platte River Basin," *Public Health Service, U. S. Dept. of HEW,* (1963).

"The Cost of Clean Water - State and Major River Basin Municipal Tables," Volume IV, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968).

"The Cost of Clean Water - Summary Report," Vol. I, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968).

"Data Report Youghiogheny River Survey November 1960-January, 1963," Thomas C. Hopkins, Jr., *Maryland Water Pollution Control Commission,* (1963).

"Definite Plan Report on Tower, Greenwood, and Yankton Units," Missouri Oahe Projects Office, *Bureau of Reclamation, U. S. Dept. of the Interior,* (1963).

"Development of Water Resources in Appalachia, 2nd Draft," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968)

"Effects of Pollution on Aquatic Life Resources of the South Platte River Basin in Colorado," Volumes I and II, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1967).

"Establishment of Water Quality Standards and Classifications for Interstate Waters in the State of Georgia," *Georgia Water Quality Control Board,* (1967.

"FWPCA Presentations ORSANCO Engineering Committee Seventieth Meeting," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1969).

"The Federal Water Pollution Control Program -- In Retrospect and in Prospect," John T. Barnhill, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968).

"Final Report on Kansas City Pollution Survey Using IR Detection Techniques," E. C. Cannard and J. G. Hogan, *HRB-Singer, Inc.,* (1961).

"Fish Kills by Pollution 1966," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1967).

"Further Studies on the Introduced Asiatic Clam (Corbicula) in Tennessee," R. M. Sinclair and B. S. Isom, *Tennessee Dept. of Public Health,* (1963).

"The Future of Instrumentation in Water Pollution Control," J. H. McDermott, D. H. Ballinger and W. T. Sayers, *Instrument Society of America,* (1968).

"Future Water Requirements for Municipal Use - Water Resources in the U. S.," *Select Committee on Natural Water Resources, S. Res. 48 Eighty-Sixth Congress,* (1960).

"General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee," *Tennessee Stream Pollution Control Board,* (1967).

"Generalized Streamflow Probabilities High Flow Plains Snow Region," *Missouri Basin Inter-Agency Committee,* (1967).

"Generalized Streamflow Probabilities -- High Flows, Sub-Basin 4, Eastern Dakota Tributaries," *Missouri Basin Inter-Agency Committee,* (1967).

"Generalized Streamflow Probabilities -- High Flows, Sub-Basin 5, Platte-Niobrara Basins," *Missouri Basin Inter-Agency Committee,* (1967).

"Generalized Streamflow Probabilities -- High Flows, Sub-Basin 7, Kansas Basin," Missouri Basin Inter-Agency Committee, (1967).

"Generalized Streamflow Probabilities -- High Flows, Sub-Basin 6, Middle Missouri River Tributaries," Missouri Basin Inter-Agency Committee, (1967).

"Generalized Streamflow Probabilities -- High Flows, Sub-Basin 8, Lower Missouri River Tributaries," Missouri Basin Inter-Agency Committee, (1966).

"Ground-Water Pollution in the South Platte River Valley Between Denver and Brighton Colorado," Public Health Service, U. S. Dept. of HEW, (1965).

"Ground-Water Pollution in the Middle and Lower South Platte River Basin of Colorado," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1967).

"Heated Discharges - Their Effect on Streams," Publication No. 3, Pennsylvania Dept. of Health, (1962).

"High-Flow Volume-Frequency Curves for Selected Durations Eastern Dakota Tributaries," Missouri Basin Inter-Agency Committee, (1967).

"High-Flow Volume-Frequency Curves for Selected Durations Kansas Basin," Missouri Basin Inter-Agency Committee, (1967).

"High-Flow Volume-Frequency Curves for Selected Durations Lower Missouri River Tributaries," Missouri Basin Inter-Agency Committee, (1966).

"High-Flow Volume-Frequency Curves for Selected Durations Missouri River Main Stem," Missouri Basin Inter-Agency Committee, (1967).

"High-Flow Volume-Frequency Curves for Selected Durations Middle Missouri River Tributaries," Missouri Basin Inter-Agency Committee, (1967).

"High-Flow Volume-Frequency Curves for Selected Durations Platte-Niobrara Basins," Missouri Basin Inter-Agency Committee, (1967).

"Highlights of Report: Water Quality and Management Snake River Basin," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1968).

"Houseboat Waste Characteristics and Treatment," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1967).

"Illinois Sanitary Water Board Rules & Regulations SWB-9 Water Quality Criteria Interstate Waters Wabash River and Tributary Streams Crossing into Indiana, Critera and Implementation," State of Illinois Sanitary Water Board, (1966-1967).

"Illinois Sanitary Water Board Rules & Regulations SWB-10 Water Quality Criteria Interstate Waters Ohio River and Saline River, Criteria and Implementation," State of Illinois Sanitary Water Board, (1966-1967).

"Indiana Water Quality Monitor Station Records - Rivers and Streams, 1957-1966," Indiana State Board of Health and Stream Pollution Control Board, (1957-1967).

"Industrial Plants Visited and Not Sampled Supplement to the Basic Report - A Study of Industrial Waste Pollution in the South Platte River Basin," Appendix A and B, Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1966).

"Infiltration Data," Soil Conservation Service, U. S. Dept. of Agriculture, (1966).

"Information Bulletin for Public Hearings on Proposed Revisions of Water Quality Standards for Interstate and Intrastate Waters of Nebraska," Nebraska Water Pollution Control Council, State Dept. of Health, (1968).

"Instrumentation for Water Quality Management in the Ohio Valley," W. L. Klein, D. A. Dunsmore and R. K. Horton, Forum on the Control of Water Quality, American Society for Testing and Materials, (1965).

"Intensive Study of the Water at Critical Points on the Monongahela, Allegheny and Ohio Rivers in the Pittsburgh, Pennsylvania Area," Report to the FWPCA No. PH-86-64-124, by Graduate School of Public Health, University of Pittsburgh, (1966).

"James River Basin Water Pollution Investigation," State of North Dakota, State of South Dakota, and Public Health Service of Missouri, (1952).

"Kansas River Basin, Planning Status Report, Water Resource Appraisals for Hydroelectric Licensing," Federal Power Commission, Bureau of Power, (1966).

"Kansas Streamflow Characteristics, Base Flow Data," Technical Report Number 6A, Busby, M. W. and Armentrout, G. W., Kansas Water Resources Board, (1965).

"Kansas Streamflow Characteristics Part 2 Low-Flow Frequency," Technical Report Number 2, Furness, L. W., Kansas Water Resources Board (1960).

"Kansas Streamflow Characteristics, Part 3, Flood Frequency," Technical Report Number 3, Ellis, W., and Edelen, W., Jr., Kansas Water Resources Board, (1960).

"Kansas Streamflow Characteristics, Part 5, Storage Requirements to Control High Flow," Technical Report Number 5, Furness, L. W., Burns, C. V. and Busby, M. W., Kansas Water Resources Board, (1964).

"Kansas Water Resources Development," U. S. Army Corps of Engineers, (1967).

"Kentucky Water Quality Standards for Interstate Waters Ohio, Mississippi, Tennessee, Cumberland and Big Sandy Rivers," Kentucky Water Pollution Control Commission, (1967).

"A Limnological Study of the Upper Ohio River Hydromechanics and Radiation Phase of the Study," Final Report to the Atomic Energy Commission, Graduate School of Public Health, University of Pittsburgh, (1962).

"A Limnological Study of the Upper Ohio River, Progress Report to the Atomic Energy Commission," Graduate School of Public Health, University of Pittsburgh, (1961).

"Lower-Missouri River Basin Water Pollution Investigation; A Cooperative State-Federal Report on Water Pollution, October, 1952," Water Pollution Series No. 47," Iowa Dept. of Health, Kansas Board of Health, Minnesota Dept. of Health, South Dakota Dept. of Health and Federal Security Agency, Public Health Service, (1952).

"Main Stem Reservoir Effects on Water Quality in the Central Missouri River," J. Neel, H. P. Nicholson and Allan Hirsch, Public Health Service, U. S. Dept. of HEW, (1963).

"Man and the Waters of the Upper Ohio River Basin," Special Publication No. 1, Pymatuning Laboratory of Field Biology, University of Pittsburgh, (1965).

"Meat Industry Waste Study Supplement to the Basic Report - A Study of Industrial Waste Pollution in the South Platte River Basin," Appendix D, Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1966).

"Meeting the Challenge of Water Pollution," Joe G. Moore, Jr., Dickey Data, (1968).

"Mississippi Water Quality Standards, Part 1 of 2" Mississippi Air and Water Pollution Control Commission, (1967).

"Missouri River Basin Comprehensive Framework Study Analysis of Freeze-Thaw Dates Missouri Basin Streams," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Evaporation Estimates for the Missouri River Basin," Missouri Basin Inter-Agency Committee (1966).

"Missouri River Basin Comprehensive Framework Study Generalized Streamflow Probabilities High Altitude Snow Region," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Multi-Annual Precipitation Probabilities Eastern Dakota Tributaries," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Multi-Annual Precipitation Probabilities Kansas Basin," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Multi-Annual Precipitation Probabilities Lower Missouri River Tributaries," Missouri Basin Inter-Agency Committee, (1966).

"Missouri River Basin Comprehensive Framework Study Multi-Annual Precipitation Probabilities Middle Missouri River Tributaries," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Multi-Annual Precipitation Probabilities Missouri River Basin and the Drainage Above Sioux City, Iowa," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Multi-Annual Precipitation Probabilities Platte-Niobrara Basins," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Precipitation Probability Levels and Durations of 1, 2, 4, and 8 W Weeks," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Preliminary Economic Projections for the Eastern Dakota Tributaries Subregion," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Preliminary Economic Projections for the Kansas River," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Preliminary Economic Projections for the Lower Missouri River," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Preliminary Economic Projections for the Middle Missouri River," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Sedimentation Eastern Dakota Tributaries," *Missouri Basin Inter-Agency Committee*, (1968).

"Missouri River Basin Comprehensive Framework Study Sedimentation Lower Missouri River Tributaries," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Sedimentation Middle Missouri River Tributaries," *Missouri Basin Inter-Agency Committee*, (1968).

"Missouri River Basin Comprehensive Framework Study Selected Climatic Maps," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Streamflow Characteristics in the Eastern Dakota Tributaries Flow-Duration, High-Flow and Low-Flow Tables for Selected Stations Through 1963," *Missouri Basin Inter-Agency Committee*, (1967).

"Missouri River Basin Comprehensive Framework Study Streamflow Characteristics in the Kansas Basin Flow-Duration, High-Flow and Low-Flow Tables for Selected Stations Through 1963," *Missouri Basin Inter-Agency Committee*, (1966).

"Missouri River Basin Comprehensive Framework Study Streamflow Characteristics in the Platte-Niobrara Basins Flow-Duration, High-Flow and Low-Flow Tables for Selected Stations Through 1963," *Missouri Basin Inter-Agency Committee*, (1966).

"Missouri River Basin Comprehensive Framework Study Streamflow Characteristics in the Western Dakota Tributaries Flow-Duration, High-Flow and Low-Flow Tables for Selected Stations Through 1963," Missouri Basin Inter-Agency Committee, (1967).

"Missouri River Basin Comprehensive Framework Study Streamflow Characteristics Lower Missouri River Tributaries Flow-Duration, High-Flow and Low-Flow Tables for Selected Stations Through 1963," Missouri Basin Inter-Agency Committee, (1966).

"Missouri River Basin Comprehensive Framework Study Streamflow Characteristics Upper Missouri River Tributaries Flow-Duration, High-Flow and Low-Flow Tables for Selected Stations Through 1963," Missouri Basin Inter-Agency Committee, (1966).

"Missouri River Basin Sioux City to Mouth, Planning Status Report, Water Resource Appraisals for Hydroelectric Licensing," Federal Power Commission, Bureau of Power, (1966).

"Missouri River Hydrographic Survey, 1967, Omaha District," U. S. Army Corps of Engineers, (1967).

"1967 Missouri River Hydrographic Survey, Rulo, Nebraska to the Mouth," Corps of Engineers, Dept. of the Army, (1967).

"Missouri River Basin - Conservation, Control, and Use of Water Resources of the Missouri River Basin in Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri," Bureau of Reclamation, U. S. Dept. of the Interior, (1944).

"Missouri River Main Stem Reservoirs, Summary of Actual 1967-68 Operations and Annual Operating Plan for 1968-69," Reservoir Control Center, U. S. Army Engineer Division, (1968).

"Monitoring Water Quality for Pollution Control," Richard S. Green, Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1966).

"Monthly Streamflow Tables and Depletion Estimates," Missouri Basin Inter-Agency Committee, (1966).

"Municipal, Industrial and Quality Control Water Demands for the Missouri Basin, Subbasin 5," Missouri Basin Inter-Agency Committee, (1967).

"Municipal, Industrial and Quality Control Water Demands for the Missouri Basin, Subbasin 6," *Missouri Basin Inter-Agency Committee*, (1967).

"Municipal, Industrial and Quality Control Water Demands for the Missouri Basin, Subbasin 7," *Missouri Basin Inter-Agency Committee*, (1967).

"Municipal, Industrial and Quality Control Water Demands for the Missouri Basin, Subbasin 8," *Missouri Basin Inter-Agency Committee*, (1968).

"Municipal Waste Report, Metropolitan Denver Area, South Platte River Basin," *Public Health Service, U. S. Dept. of HEW*, (1965).

"Municipal Water Facilities Communities of 25,000 Population and Over United States and Possessions as of January 1, 1964," *Public Health Service, U. S. Dept. of HEW*, (1964).

"National Estuarine Inventory Handbook of Descriptors," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1968).

"National Water Quality Network - Annual Compilation of Data," Public Health No. 663, *U. S. Dept. of HEW*, (1957-1963).

"Niobrara, Lower Platte and Kansas River Basins, 1967 Operations, 1968 Outlook," *Bureau of Reclamation, U. S. Dept. of the Interior*, (1968).

"The Ohio River Basin," *League of Women Voters Educational Fund*, (1964).

"Ohio River Basin Comprehensive Survey, Volumes I-XV," *U. S. Army Engineer Division*, Ohio River, Cincinnati, Ohio, (1964-1969).

"Ohio River Markland Pool," *Ohio River Division of Engineers, U. S. Army*, (1968).

"Ohio River Pollution Control - Three Volumes, Report of the Ohio River Committee, 78th Congress, 1st Session," *House Document No. 266*, (1943).

"Ohio Water Pollution Control Board Annual Report for 1968," *Ohio Dept. of Health*, (1969).

"Optimum Sampling Interval for Water Quality Monitoring in Tidal Estuaries," Charles G. Gunnerson, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1965).

"ORSANCO - Annual Reports, First to Twentieth, *Ohio River Valley Water Sanitation Commission*, (1949-1968).

"ORSANCO Quality Monitor, Monthly Report of Water Quality Conditions," *Ohio River Valley Water Sanitation Commission*, (1968-1969).

"Osage-Gasconade River Basins, Planning Status Report, Water Resource Appraisals for Hydroelectric Licensing," *Federal Power Commission, Bureau of Power*, (1966).

"Outfall Study - Location and Sampling Results - Supplement to the Basic Report - A Study of Industrial Waste Pollution in the South Platte River Basin," Appendix C, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1966).

"Pennsylvania Surface Water Quality Network," *Pennsylvania Department of Health*, (1962-1969).

"Personal Communications Re Certification of Administrative Rules Filed with the Secretary of State," *Florida Air and Water Pollution Control Commission*, (1968).

"Personal Communications to Federal Water Pollution Control Administration, Attachment, Status of Sewage Treatment Facilities for Various Interstate Waters," *State of West* Virginia, (1968).

"Personal Communications to Federal Water Pollution Control Administration," *Mississippi Air and Water Pollution Control* Commission, (1967).

"Personal Communication to Federal Water Pollution Control Administration," *State of Georgia State Water Quality Control Board*, (1967).

"Personal Communication to Governor of Colorado," *U. S. Dept. of the Interior*, (1968).

"Personal Communications to U. S. Dept. of the Interior," *Kentucky Water Pollution Control Commission*, (1967).

"Pesticides in Water," R. S. Green and S. K. Love, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1967).

"Physical and Chemical Water Quality from the Effects of Mine Drainage in Western Maryland," Thomas C. Hopkins, Jr., *Maryland Dept. of Water Resources*, (1967).

"Plan of Implementation Covering Municipal and Industrial Wastes," *State of Wyoming*, (1968).

"Plan of Implementation for Water Quality Control and Pollution Abatement Kansas," *Kansas State Board of Health*, (1967).

"Platte River Basin, Planning Status Report, Water Resource Appraisals for Hydroelectric Licensing," *Federal Power Commission, Bureau of Power*, (1966).

"Pollution Abatement - Water Resources in the United States," *Select Committee on Natural Water Resources, S. Res. 48 86th Congress*, (1960).

"Pollution Caused Fish Kills 1967," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1968).

"Pollution of Interstate Waters, Missouri River, Volume 1 and 2, Transcript of Hearing," *Public Health Service, U. S. Dept. of HEW*, (1959).

"Pollution of Interstate Waters of the Mississippi River in the St. Louis Metropolitan Area," *Division of Health, State of Missouri, Public Health Service, U. S. Dept. of HEW, Sanitary Water Board, State of Illinois, Bi-State Development Agency of the Missouri-Illinois Metropolitan Area*, (1958).

"Pollution of Interstate Waters, Transcript of Conference, Missouri River, River Miles 846.5 - 642.3 Inclusive," *Public Health Service, U. S. Dept. of HEW*, (1958).

"Pollution Surveillance and Water Quality Monitoring in the United States," Richard S. Green, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1966).

"A Preliminary Appraisal - Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems," *Public Health Service, U. S. Dept. of HEW*, (1964).

"Preliminary Economic Projections for the Platte Subregion," *Missouri Basin Inter-Agency Committee*, (1966).

"The Present and Projected Agricultural Economy of Selected Counties of the Mobile-Tambigbee-Warrior River Basins," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1967).

"Present Temperature Conditions," Keith O. Schwab, FWPCA Presentations ORSANCO Engineering Committee, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1969).

"Problems of Combined Sewer Facilities and Overflows," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1967).

"Proceedings - Conference in the Matter of Pollution of the South Platte River Basin in the State of Colorado - Second Session," Volumes I, II, and III, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (April, 1966).

"Proceedings Conference in the Matter of Pollution of the South Platte River Basin in the State of Colorado, Second Session, Denver, Colorado Reconvened, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (November, 1966).

"Proceedings of Symposium on Waste Stabilization Lagoons: Review of Research and Experience in the Design, Construction, Operation, and Maintenance of Waste Stabilization Lagoons," *Public Health Service*, (1960).

"Progress Evaluation Meeting in the Matter of Pollution of the Interstate Waters of the Missouri River, Omaha, Nebraska, Area (Nebraska-Iowa-Missouri-Kansas)," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior*, (1967).

"Quality of Surface Waters in Illinois. Bulletin 45," T. E. Larson and B. O. Larson, *Illinois State Water Survey*, (1957).

"Quality of Surface Water in Illinois, 1956-1966, Bulletin 54," Robert H. Harmeson and T. E. Larson, *Illinois State Water Survey*, (1969).

"Quality of Surface Waters of the United States, Part 1-4," *Geological Survey, Dept. of the Interior*, (1948-60).

"Quality of Surface Waters of the United States, Part 5-6," *Geological Survey, Dept. of the Interior*, (1950-60).

"Radioactive Waste Disposal in the Upper Ohio River Basin with Emphasis Upon the Shippingport Atomic Power Station," A report to the Commonwealth of Pennsylvania Department of Health, *Graduate School of Public Health, University of Pittsburgh*, (1962).

"Regional Inventories - Municipal Waste Facilities," Public Health Service, U. S. Dept. of HEW, (1962).

"Regional Inventories - Municipal Water Facilities," Public Health Service, U. S. Dept. of HEW, (1963), plus computer printout of 1968 data.

"Regulatory Actions for the Control of Sewage, Industrial Wastes, and Other Substances," Ohio River Valley Water Sanitation Commission, (1964).

"Report of Chattahoochee River Investigation Proposed Columbia Reservoir Project," Public Health Service, U. S. Dept. of HEW, (1959).

"Report of Covsa River System Georgia-Alabama," Public Health Service, U. S. Dept. of HEW, (1963).

"Report of Supplemental Survey North Platte River Torrington, Wyoming - Bridgeport, Nebraska," Nebraska Dept. of Health - Wyoming Dept. of Public Health, (1963).

"Report Survey North Platte River Torrington, Wyoming - Bridgeport, Nebraska," Nebraska Dept. of Health, Wyoming Dept. of Public Health, (1962).

"A Report of Water Pollution in the Grand-Chariton Drainage Basins," Iowa Dept. of Health, Missouri Div. of Health and Public Health Service of Missouri, (1952).

"A Report of Water Pollution in the Kansas River Basin," Colorado Dept. of Public Health, Kansas State Board of Health, Nebraska Dept. of Health, and Public Health Service of Missouri, (1953).

"A Report of Water Pollution in the Osage (Marais des Cygnes) - Gasconade Drainage Basins," Kansas State Board of Health, Missouri Div. of Health, Public Health Service of Missouri, (1952).

"A Report of Water Pollution in the South Platte River Basin," Colorado Dept. of Public Health, Nebraska Dept. of Health, Wyoming Dept. of Public Health and Public Health Service of Missouri, (1953).

"A Report of Water Pollution in the Yellowstone Drainage Basin," Montana Board of Health, North Dakota Dept. of Health, Wyoming Dept. of Public Health and Public Health Service of Missouri, (1952).

"Report on Interstate Pollution of the Missouri River Yankton, South Dakota, to Omaha, Nebraska, Supplemental to Water Pollution Series No. 47 and Water Pollution Series No. 56," *Public Health Service, U. S. Dept. of HEW*, (1958).

"Report on North Platte River Survey Wyoming-Nebraska September and November, 1961," Public Health Service, Robert A. Taft Sanitary Engineering Center, *U. S. Dept. of HEW*, (1962).

"Report on Pollution of Interstate Waters of the Mouth of the Savannah River, Georgia - South Carolina," West, W.W., C.E. Runas, J.M. Fairall, T. A. Wastler and F. W. Kittrell, *U. S. Dept. of HEW*, (1964).

"Report on Pollution of the Chattahoochee River Alabama-Georgia," A. W. West, *Federal Water Pollution Control Administration, U. S. Dept. of HEW*, (1966).

"Report on Pollution of the Interstate Waters of the Monongahela River System," A. D. Sidio, K. M. Mackenthun, *Public Health Service, U. S. Dept. of HEW*, (1963).

"Report on Pollution of Interstate Waters of the North Fork Holston River and of Holston and Tennessee Rivers Virginia-Tennessee," *Public Health Service, U. S. Dept. of HEW*, (1960).

"Report on Pollution of Interstate Waters of the North Platte River, Torrington, Wyoming to Bridgeport, Nebraska," *Public Health Service, U. S. Dept. of HEW*, (1960).

"Report on Pollution of Interstate Waters of the Pearl and East Pearl Rivers Louisiana-Mississippi," *Public Health Service, U. S. Dept. of HEW*, (1963).

"A Report on Pollution of the Nation's Water by Oil and Other Hazardous Substances," Requested by President Johnson, *Secretary of the Interior and Secretary of Transportation*, (1968).

"Report on the South Platte River Basin," *Bureau of Reclamation, U. S. Dept. of the Interior*, (1959).

"Report on the South Platte River Basin Colorado-Wyoming-Nebraska," Bureau of Reclamation, Region 7, *U. S. Dept. of the Interior*, (1959).

"Report on Water Quality Criteria and Plan for Implementation the Indiana Waters of the Main Stem of the Ohio River and Its Indiana Tributary Basins," Stream Pollution Control Board of the State of Indiana, (1967).

"Report on Water Quality Criteria and Plan for Implementation Main Stem of the Ohio River Contiguous to Ohio and Kentucky Excluding the Waters of the Licking and Big Sandy Rivers Proposed by Kentucky Water Pollution Control Commission," Kentucky Water Pollution Control Commission, (1967).

"Report on Water Quality Criteria and Plan for Implementation Patoka River Basin and the Indiana Waters of the Lower Wabash River Basin Excluding the Waters of the White River Basin, State of Indiana," Stream Pollution Control Board of the State of Indiana, (1967).

"Report on Water Quality Criteria and Plan for Implementation Upper and Middle Wabash River Basins (Down to Terre Haute) State of Indiana," Stream Pollution Control Board of the State of Indiana, (1967).

"Resolution Regarding Amended Criteria of Stream-Water Quality for Various Uses Adopted by the Board on October 10, 1967," Water Pollution Control Board Ohio Department of Health, (1967).

"River Basin Water Quality Criteria, Kansas," Kansas State Board of Health, (1967).

"River-Quality Conditions during a 16-week Shutdown of Upper Ohio Valley Steel Mills," Ohio River Valley Water Sanitation Commission, (1961).

"Rules of State Water Quality Control Board," Georgia Water Quality Control Board, (1965).

"Satilla-St. Marys Basin-Technical Memoranda for Water Supplies Pollution Abatement and Public Health," U. S. Dept. of HEW, (1962).

"Savannah Basin-Technical Memoranda for Water Supplies Pollution Abatement and Public Health," U. S. Dept. of HEW, (1962).

"Second Conference and Interstate Pollution of North Fork Holston River," Division of Water Supply and Pollution Control, U. S. Public Health Service, (1962).

"Sewage and Industrial Waste Treatment Requirements and Effluent Criteria," Personal Communications and Technical Release, State of Illinois Sanitary Water Board, (1967).

"Sewer and Sewage Treatment Plant Construction Cost Index," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1967).

"Showdown for Water," Federal Water Pollution Control Administration, U. S. Dept of the Interior, (1968).

"Snow Survey and Soil Moisture Data in the Mountainous Portions of the Missouri River Basin," Missouri Basin Inter-Agency Committee, (1967).

"South Platte River Basin Irrigation of Vegatables with Sewage-Polluted Water," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1967).

"South Platte River Basin, River Mileage Index," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1966).

"State of Georgia Water Quality Control Act - Act No. 870 (H. B. 730) as Amended Through 1966," State of Georgia, (1966).

"State of Ohio Water Quality Standards and Plan of Implementation," Water Pollution Control Board, Ohio Dept. of Health, (1967).

"State of Virginia Water Quality Standards," State Water Control Board, (1967).

"Statement Water Quality Management & Pollution Control Program in Iowa, Kansas, Missouri & Nebraska," Volume I, Public Health Service, U. S. Dept. of HEW, (1964).

"Statement Water Quality Management & Pollution Control Program in Iowa, Kansas, Missouri and Nebraska," Volume II, Public Health Service, U. S. Dept. of HEW, (1964).

"Statewide Water Quality Surveillance Network 1968 Survey Results," John R. Longwell and Richard L. Sharpless, *Maryland Dept. of Water Resources,* (1969).

"Stream Pollution by Coal Mine Drainage in Appalachia," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1967).

"Storet Data for Ohio, Tennessee, Missouri and Southeastern River Basins," *U. S. Dept. of the Interior,* (1957-1969).

"Stream Classification for Surface Waters of Colorado Including Stream Quality Standards, Plan of Implementation, Enforcement Procedures," *Colorado State Dept. of Public Health,* (1967).

"Stream Pollution by Coal Mine Drainage in Appalachia," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1969).

"Streamflow Characteristics in the Middle Missouri River Tributaries," Work Group on Hydrologic Analyses and Projections, *Missouri Basin Inter-Agency Committee,* (1967).

"Stream flow Characteristics Missouri River Main Stem," *Missouri Basin Inter-Agency Committee,* (1966).

"Study and Interpretation of the Chemical Characteristics of Natural Water," John D. Hem, Water-Supply Paper 1473, *U. S. Geological Survey,* (1959).

"Study of Omaha, Nebraska Meat-Packing Wastes," *Public Health Service, U. S. Dept. of HEW,* (1965).

"A Study of the Pollution and Natural Purification of the Ohio River, IV. A Resurvey of the Ohio River Between Cincinnati, Ohio, and Louisville, Ky., Including a Discussion of the Effects of Canalization and Changes in the Sanitary Conditions Since 1915-1916," H. R. Crohurst, Public Health Bulletin No. 204, *U. S. Public Health Service,* (1933).

"A Study of the Pollution and Natural Purification of the Ohio River, I. The Plankton and Relation Organisma," Purdy, Public Health Bulletin No. 131, *Public Health Service,* (1922).

"A Study of the Pollution and Natural Purification of the Ohio River, II. Report on Surveys and Laboratory Studies," W. H. Frost, Public Health Bulletin No. 143, *U. S. Public Health Service,* (1924).

"A Study of the Pollution and Natural Purification of the Ohio River, III. Factors Concerned in the Phenomena of Oxidation and Reaeration," Streeter and Phelps, Public Health Bulletin No. 146, U. S. Public Health Service, (1925).

"Studies on the Aquatic Ecology of the Upper Ohio River System," Special Publication No. 3 Pymatuning Laboratory of Ecology, University of Pittsburgh, (1965).

"Summary Report on Quality of Interstate Waters Little Sioux River (Minnesota-Iowa)," Public Health Service, U. S. Dept. of HEW, (1961).

"Surface Water Supply of the United States - Part 2 - South ATlantic Slope and Eastern Gulf of Mexico Basins," Geological Survey, Dept. of the Interior, (1930-1959).

"Surface Water Supply of the United States Part 3 - Ohio River Basin," Geological Survey, Dept. of the Interior, (1930-59).

"Surface Water Supply of the United States Part 6 - Missouri River Basin," Geological Survey, Dept. of the Interior, (1930-1959).

"Surveillance Operations in the Control of Water Pollution on a National Scale," James H. McDermott, Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1967).

"Technical Memoranda for Water Supplies Pollution Abatement and Public Health," Apalachicola-Chattahoochee-Flint Basin, Public Health Service, U. S. Dept. of HEW, (1962).

"Technical Memoranda for Water Supplies Pollution Abatement and Public Health," Ochlockonee Basin, Public Health Service, U. S. Dept. of HEW, (1962).

"Choctawhatchee-Periodido Basins Technical Memoranda for Water Supplies Pollution Abatement and Public Health, Public Health Service, U. S. Dept. of HEW, (1962).

"Technical Programs," Clean Water Fact Sheet, Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1968).

"Trace Metals in Waters of the United States: A Five Year Summary of Trace Metals in Rivers and Lakes of the United States (October 1, 1962-September 30, 1967)," John F. Kopp and Robert C. Kroner, Federal Water Pollution Control Administration, Dept. of the Interior, (1969).

"Transcript of Conference - Pollution of Interstate Waters, Missouri River, Kansas City Metropolitan Area," Public Health Service, U. S. Dept. of HEW, (1957).

"Transcript of Conference on Pollution of Interstate Waters of the North Platte River," Wyoming-Nebraska, U. S. Dept. of Hew, (1961-1962).

"Transcript of Hearing Pollution of Interstate Waters Missouri River," Public Health Service, U. S. Dept. of HEW, (1959).

"Transcript of Hearing Pollution of Interstate Waters, Missour River and Connecting or Tributary Waters in or Adjacent to the Kansas City's Metropolitan Area," Public Health Service, U. S. Dept. of HEW, (1960).

"Transcript of Proceedings Progress Evaluation Meeting of Conferees in the Matter of Pollution of the Interstate Waters of the Missouri River-Omaha Area February, 1965 and Appended Summaries of First Session of Conference 1957 and Second Session of Conference 1964," U. S. Dept. of HEW, (1965).

"Transcript of Proceedings Progress Evaluation Meetings of Conferees in the Matter of Pollution of the Interstate Waters of the Missouri River-Omaha Area January and March, 1966," U. S. Dept. of HEW, (1966).

"Transcript of Proceedings Progress Evaluation Meeting in the Matter of Pollution of the Interstate Waters of the Missouri River and Tributary Waters, Kansas City's Metropolitan Area and Appended Summary of Conference December, 1957," U. S. Dept. of HEW, (1965).

"Unpublish Data," - Upper Ohio Basin Office, Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1962-1969).

"Virginia Water Quality Standards Addendum Sheet-Clarification of Board Policies and Procedures with Respect to Adoption and Implementation of Interstate Standards of Water Quality," State Water Control Board, (1967).

"Water Quality Criteria for Interstate and Coastal Waters State of Mississippi," Mississippi Air and Water Pollution Control Commission, (1968).

"Water Quality Criteria and Plan for Implementation and Enforcement for the Surface Waters of Iowa," Iowa Water Pollution Control Commission, State Dept. of Health, (1967).

"Water Quality Criteria and Plan for Implementation Interstate Streams, Report on," State of West Virginia, (1967).

"Water Quality Data for Streams and Reservoirs in the Tennessee River Basin," Tennessee Valley Authority, (1969).

"Water Quality Middle Basin Tributary Streams South Platte River Basin Summer 1965," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1967).

"Water Quality Management - Water Resources Activities in the U. S.," S Res. 48 Eighty-Sixth Congress, (1960).

"Water Quality Management in Transition," Joe G. Moore, Jr., Civil Engineering, (1968).

"Water Quality Standards Conference, State of Iowa, Iowa Interstate Waters of the Missouri River Basin, Council Bluffs, Iowa," Federal Water Pollution Control Administration, U. S. Dept. of the Interior, (1969).

"Water Quality Standards--Current Policy Issues," Max N. Edwards, U. S. Dept. of the Interior, (1968).

"Water Quality Standards: The Federal Perspective -- Progress Toward Objectives," Allan Hirsch, L. Agee, and Burd, Water Pollution Control Federation, (1967).

"Water Quality Standards for Waters of Alabama and A Plan for Implementation," State of Alabama Water Improvement Commission, (1967).

"Water Quality Standards for Colorado," Federal Water Pollution Control Federation, Colorado Department of Public Health, (1968).

"Water Quality Standards for Interstate Waters in Wyoming," Wyoming Department of Health, (1968).

"Water Quality Standards Minor Missouri Riber Tributaries, Missouri River Basin," Missouri Water Pollution Board, (1968).

"Water Quality Standards Mississippi River, Upper Mississippi and Southwest-Lower Mississipp," *Missouri Water Pollution Board*, (1968).

"Water for the Future of Kansas-Kansas Basins Project Interim Report No. 1," *Bureau of Reclamation, U. S. Dept. of the Interior,* (1968).

"Water Pollution Control 1969-1973, The Federal Costs, A Report to the Congress," *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968).

"Water Pollution Control and Quality Management Programs of the States of Alabama, Georgia, Mississippi and Tennessee," Volume II, *Public Health Service, U. S. Dept. of HEW,* (1964).

"Water Pollution Surveillance in the United States, Report Number 1, Missouri River Study," *Public Health Service, U. S. Dept. of HEW,* (1964).

"Water Quality Basic Data - Southeastern River Basins," *Public Health Service, U. S. Dept. of HEW,* (1961).

"Water Quality Criteria," Report of the National Technical Advisory Committee to the Secretary of the Interior, *Federal Water Pollution Control Administration,* (1968).

"Water Quality Standards Missouri River, Missouri River Basin," *Missouri Water Pollution Board,* (1968).

"Water Quality Standards Osage & Gasconade Rivers and Tirbutaries, Osage-Gasconade River Basin - Missouri River Basin," *Missouri Water Pollution Board,* (1968).

"Water Quality Standards for Pennsylvania's Interstate Streams, Excerpt from a Report by the Pennsylvania Sanitary Water Board," Division of Sanitary Engineering, Bureau of Environmental Health, *Pennsylvania Dept. of Health,* (1967).

"Water Quality Standards for the Surface Waters of South Dakota," *The South Dakota Committee on Water Pollution, South Dakota State Dept. of Health,* (1967).

"Water Quality Surveillance in Water Resource Development and Control," H. McDermott, *Federal Water Pollution Control Administration, U. S. Dept. of the Interior,* (1968).

"Water Quality and Flow Variations, Ohio River and Tributaries 1956-57," *Ohio River Valley Water Sanitation Commission*, (1959).

"Water Quality and Flow Variations in the Ohio River 1951-1955," *Ohio River Valley Water Sanitation Commission,* (1957).

"Water Quality and Time of Travel Investigations in the Lower Kansas River Basin," *Kansas State Dept. of Health, Federal Water Pollution Control Administration,* (1967).

"Water Quality of Tennessee Surface Streams 1960-1967," *Tennessee Stream Pollution Control Board, Tennessee Dept. of Public Health,* (1960-1967).

"Water Resources Data for Alabama, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Colorado, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Florida, Part 1, Surface Water Records, Part 2, Water Qualtiy Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Georgia, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Illinois, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Indiana, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Iowa, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Kansas, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Kentucky, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Louisiana, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey,* U. S. Dept. of the Interior, (1960-1968).

"Water Resources Data for Maryland, Part 1, Surface Water Records, Part 2, Water Qualty Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Mississippi, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Missouri, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Nebraska, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for New York, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Ohio, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Pennsylvania, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for South Dakota, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Tennessee, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Virginia, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for West Virginia, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Data for Wyoming, Part 1, Surface Water Records, Part 2, Water Quality Records," *Geological Survey, U. S. Dept. of the Interior,* (1960-1968).

"Water Resources Development in Missouri," *U. S. Army Corps of Engineers,* (1967).

"Water Resources of the Pittsburgh Area, Pennsylvania," Noecker, Greeman and Beamer, Geological Survey Circular No. 315, *Geological Survey, U. S. Dept. of the Interior,* (1954).

"Water Resources of West Virginia," W. L. Doll, G. Meyer and R. J. Archer, *U. S. Geological Survey and West Virginia Dept. of Natural Resources,* (1963).

"Water Resources Development by the U. S. Army Corps of Engineers in Colorado," *Missouri River Division, Corps of Engineers, U. S. Dept. of the Army,* (1967).

"Water Resources Development by the U. S. Army Corps of Engineers in Iowa," *North Central Division, Corps of Engineers, U. S. Dept. of the Army,* (1967)

"Water Resources Development by the U. S. Army Corps of Engineers in Nebraska," *Missouri River Division, Corps of Engineers, U. S. Dept. of the Army,* (1967).

"Water Resources Development by the U. S. Army Corps of Engineers in South Dakota," *Missouri River Division, Corps of Engineers, U. S. Dept. of the Army,* (1967).

"Water Resources Regulation 4.8, General Water Quality Criteria and Specific Water Quality Standards for All Maryland Waters," *Maryland Water Resources Commission,* (1969).

"West Virginia Water Quality Network 1960-1963," *State of West Virginia Department of Natural Resources,* (1960-1963).

SECTION 9

APPENDICES

RIVER BASIN DATA AND STANDARDS

The following section contains a description of each of the river basins studied in this project. Also included are interstate water quality standards for each particular site at which water quality monitors are suggested. If two interstate state standards apply due to border sharing, each is listed. The standards as presented herein were those currently under submission at the time of this project.

Each State has listed a general criteria which are usually quite long and all inclusive. Rather than list each of these, the general water quality criteria for Pennsylvania is presented as typical. It follows:

Pennsylvania General Criteria - The water shall not contain substances attributable to municipal, industrial, or other waste discharges in concentration or amount sufficient to be inimical or harmful to the water uses to be protected to human, animal, plant, or aquatic life. Specific substances to be controlled include, but are not limited to, floating debris, oil, scum, and other floating materials: toxic substances: substances that produce color, taste, odors or settle to form sludge deposits.

APPENDIX I - OHIO RIVER BASIN

River Basin Descriptions

Ohio River

The Ohio River is formed at the junction of the Monongahela and the Allegheny Rivers at Pittsburgh, Pennsylvania and flows southwest for 981 miles to its confluence with the Mississippi River at Cairo, Illinois. Rainfall in this area averages forty inches per year. The Ohio River is the second largest tributary of the Mississippi River. Navigation is maintained by a series of locks and dams. This river has caused a number of disastrous floods, necessitating flood control projects which have been initiated on its tributaries. The Ohio River drains an area containing acid mine, industrial, municipal and agricultural wastes.

The Ohio River is affected by municipal, industrial and acid mine wastes at its headwaters in the Greater Pittsburgh region to the state line with Ohio and West Virginia. There are intermittent areas between the many small communities in which the stream recovers to a better quality.

In the Ohio-West Virginia region, there are temporary effects from the cities of East Liverpool, Weirton, Wheeling, Steubenville, Parkersburg, and Huntington. Downstream of each of these cities the river recovers from these local effects.

There are quite a number of new industrial plants outside of the cities which have been attracted to the benefits of the Ohio River. For the most part, these are well controlled from a pollution standpoint. This is true for the entire basin.

In the Ohio-Kentucky section of the Ohio River, the pollution problems occur at Portsmouth, Ohio where the Scioto River enters. Here, there is evidence of oil pollution from industrial sources which extends for a great distance downstream. The Little Miami and Miami River enter in the Greater Cincinnati region. These, along with the city, contribute inadequately treated industrial and municipal wastes to the Ohio River.

In the section of the Ohio River between Kentucky and Indiana-Illinois, the only large city is Louisville. The stream increases in width with more islands and is more sluggish than upstream. The terrain is less rugged and the flatness affects the stream.

The affect of the Kanawha and the Wabash Rivers will be discussed elsewhere in this report.

Pollution problems in the Ohio River main stem and minor tributaries include septic conditions, elevated water temperature, oxygen depletion, floating oil and grease, acid mine drainage, high total solids, and degradation of aesthetic qualities. These result in damages to propagation of fish life, municipal and industrial water supplies, and recreation uses. Pollution sources include municipal, industrial, and coal mines. Flow regulation is primarily the responsibility of the Corps of Engineers.

There are presently many tributaries and sections of the Ohio River Basin that have water pollution control needs requiring immediate action. These needs include domestic waste treatment, industrial waste treatment, and coal mine drainage control.

Immediate control of industrial pollution is needed at steel mills, power plants, and other industrial areas discharging miscellaneous wastes. Steel mills are known to discharge wastes containing high amounts of oil, scum, grease, and other floating matter.

Thermal pollution from steam-powered electric generating plants in the basin have produced intermittent fish kills. Improved operating techniques or cooling facilities can prevent recurrences.

Several other miscellaneous industrial pollution sources exist including chemical plants, railroad engine oil discharges, phenol discharges, and large quantities of acid and oxidizable wastes.

Coal mine drainage and effluents from related coal washeries have caused severe problems in the area for a number of years.

The confluence of the Allegheny and Monongahela Rivers at Pittsburgh presents a complex mixing condition because of the high acid content of the Monongahela. The proposed construction of two multi-purpose reservoirs in the Monongahela Basin, the Stonewall Jackson Reservoir on the West Fork and the Rowlesburg Reservoir on the Cheat River, will help eliminate shock acid loads in the Monongahela River which affect the quality of the Ohio River at Pittsburgh.

Pollution from commercial and pleasure watercraft is often severe. This is particularly true from boats tied up at docks and during loading or unloading procedures.

The present water quality problems in the area include high coliform counts, low pH, high acidity, hardness, iron, manganese, surface matter, total solids, and oxidizable matter.

The uses of the Ohio River from Fosters, Kentucky to the mouth include municipal and industrial water supply, navigation, recreation, fishing, and of the assimilative capacity in transporting treated waste effluents. Water quality in the reach immediately above Cincinnati appears to be generally good; however, below Cincinnati there are various degrees of degradation. This is especially true in the Markland pool and the area below Louisville, where the dissolved oxygen concentration often falls below 4.0 mg/liters. The coliform bacteria density increases downstream from Cincinnati and remains high to Evansville, Indiana.

In addition to the municipalities, there are many diversified industries located along the river that discharge their wastes directly into the river. These include chemical, power, coal, distillery, food processing, petroleum refining, detergents, fertilizer, and aluminum industries.

Through the efforts of ORSANCO and the state agencies, a major program of pollution control and surveillance is being undertaken in the Ohio River Basin. Through these efforts, all major communities on the Ohio River provide at least primary treatment for their wastes.

The basic data available for evaluation of water quality is provided by water quality monitor station records of ORSANCO, FWPCA, and the respective State Boards of Health or Sanitary Water Boards.

Tennessee River

The Tennessee River is the largest tributary of the Ohio River. It is approximately 652 miles long and joins the Ohio River at Paducah, Kentucky. The Tennessee River drains areas of Kentucky, Tennessee and Alabama. It is an important source of power.

The Tennessee River is noted for being unusually free of sediment and having a steady flow of water. This basin contains facilities of the Tennessee Valley Authority.

To understand the problem of control and abatement of pollution in the main stem of the Tennessee River, it is necessary to consider the river as a series of impoundments created by nine dams, from about 51 miles below Knoxville and to Kentucky, 22 miles above its mouth at Paducah. Five of the dams are in Tennessee, three in Alabama, and one in Kentucky.

Bacterial pollution from inadequately treated municipal and industrial wastes discharged into the main stem have rendered several reaches of the main stem unsafe for bathing, fishing, and recreational uses and undesirable for sources of domestic water supply. Bacterial pollution problems also exist in the vicinity of sanitary wastes discharged from floating vessels and associated shore facilities.

Industrial waste discharges with high calcium chloride content have increased the hardness of the water. Industrial as well as municipal wastes have placed an oxygen demand on the stream.

Waste discharges containing high nutrient concentrations have caused excessive aquatic growths and created undesirable water for recreational, domestic, and industrial uses.

Water with low dissolved oxygen concentration is released from all nine dams on the main stem of the Tennessee during the summer months.

Most industrial complexes are discharging polluting wastes that are often inadequately treated. Major pollution problems within the basin have been recognized. The polluters have been identified and corrective action either initiated or polluters notified that corrective measures must be taken.

The TVA has lead the way in the development of methods to improve the reaeration of streams (especially impounded water). They have also been a leader in structures to prevent thermal pollution from power plants.

Wabash River

The Wabash River drains the southern portions of Illinois and Indiana. It is 475 miles long and enters the Ohio River approximately 35 miles below Evansville, Indiana. This river receives effluents from primary treated municipal wastes. In addition, it receives wastes from chemical, meat packing, paper mills, wood treatment and food processing industries.

A wide variety of measures are needed to control existing and potential water pollution in the Wabash River and its headwater tributaries, so as to enhance its quality and provide for unimpaired use of the water. These measures include not only needed additional treatment but also such needs as flow regulation, institutional measures, financial assistance, and research. There are some areas where studies of potential problems are required to determine if further needs exist and, if so, what additional measures may be required. Many of the pollution problems along the main stem of the Wabash River could be greatly reduced, if not entirely eliminated, by the installation of new or additional waste treatment facilities.

A higher degree of waste treatment should be provided for many industrial wastes discharged in the main stem of the Wabash River and its tributaries.

The Wabash River receives drainage from one of the richest and most intensely farmed agricultural areas of the country. Silt from eroded farmlands and agricultural residues, such as fertilizers and pesticides, pose potential water quality problems. To minimize these problems there is a need to speed up the development of soil conservation programs and agricultural land management.

Through the efforts of the state regulatory agencies and ORSANCO, much progress had been made to abate pollution along the main stem of the Wabash River.

There is a need in Indiana and Illinois for improved control and surveillance of oil field practices to prevent both oil pollution and brine pollution of surface and ground waters in the oil field areas. The source or sources of lead which have caused concentrations in excess of 0.05 mg/l at New Harmony, Indiana, are unknown.

Further studies are needed regarding the problems caused by algae in the river and to determine if additional nutrient removal will be required beyond that which will be provided by meeting the immediate waste treatment needs.

There are producing oil wells on Mink Island and Greyville. These all have associated ponds, etc., which can be sources of oil and brine wastes.

The Wabash does not seem to be used extensively for recreational boating. Few small craft were in evidence.

Most all of the drainage area is heavily farmed. There are few areas with trees except for wind breaks around housing and fence lines. The stream has its banks lined with trees and there is vegetation on the islands. There are multipurpose dams on the Wabash River which offer flood control, low flow augmentation and recreation benefits.

The section of the Wabash River which is in the State of Ohio does not appear to be large enough that a major monitoring point need be established. The drainage is from a general farming area with no problems that are different from the nearby Indiana farms.

Kanawha River

The Kanawha River flows through the west central half of West Virginia for 97 miles and joins the Ohio River at Point Pleasant, Ohio. Into it drains organic, inorganic, and thermal wastes from a large chemical industrial complex. It also drains a coal mining, lumbering, and agricultural area. The Kanawha is navigable to Montgomery, West Virginia and provides water power to the area.

Within the Kanawha River Basin, the four major sources of water pollution result from improperly treated domestic wastes, industrial wastes, acid drainage from an inactive coal mining operation, and brine wastes from oil explorations. The water uses to be protected are those of domestic and industrial waters, agricultural uses, water-oriented recreation, the support and propagation of fish and aquatic life, and maintenance of general aesthetics and property values. Many communities in the Kanawha River Basin have inadequate or no sewage treatment facilities. Wastes from the chemical and related industries are the major problem in the Kanawha River Basin.

There are many stream reaches within the Kanawha River Basin which have water quality problems. There are common problems of pollution from active and inactive coal mining activities. Other areas have municipal and industrial waste discharges. Present waste loads have caused a dissolved oxygen depletion to nearly zero in this area during about seven months a year, in the period from early May to late November.

The Kanawha River is in a very steep, walled river valley. The small flood plain is lined in the Charleston, West Virginia area with chemical industrial complexes. The balance of the land is given over to small towns. There is very little land available for adequate industrial waste treatment facilities. The section above the headwaters of the Kanawha in the Gauley River and the New River are affected severely by acid mine drainage. This compounds the problems of adequate industrial waste treatment. The reach of the river downstream from the Winfield Lock and Dam has a few small towns and almost no industry.

Monongahela River Basin

Within the Monongahela River Basin, the major water pollution problems result from drainage from active and inactive coal mining operations, and from municipal wastes with no treatment or with inadequate treatment. Various pollution control measures are needed to abate septic conditions, increase the dissolved oxygen content, reduce concentrations of acidity, iron, manganese, hardness, sulfate, and other mineralizing elements, increase the pH, and reduce bacteria, solids concentration and resulting sludge depositions, nutrients, toxic substances and taste and odor producers. Principle uses of the Monongahela River are for navigation, municipal, industrial, agricultural supply, body contact recreation, support and propagation of fish and other aquatic life, general aesthetics and property values. Mine drainage contributes the most damaging and widespread pollution problem in the basin.

Domestic pollution is the second most serious problem in the basin, even though the acid content of many streams masks the effects of municipal wastes. Needs range from construction of sewage treatment facilities at towns and communities to upgrading existing facilities to secondary, and, in some cases, more advanced treatment measures. Chlorination of the final treatment effluent is necessary in all cases. Many communities have chlorination facilities which are used improperly, when at all.

The third general type of wastes are of industrial origin. In that section of the Monongahela River which is in the Greater Pittsburgh region, there are industrial wastes. The State of Pennsylvania and ORSANCO have done much to reduce these wastes. There are efforts now to reduce these industrial wastes while at the same time applying great effort to reduction of municipal and coal mining wastes.

Sewage pollution including garbage and litter from commercial tow boats on navigable waterways and from pleasure craft on rivers and lakes is becoming a recognizable problem.

Extensive studies and cooperative demonstation research projects are underway to determine the technological and economic feasibility of various methods of eliminating the pollution arising from inactive or abandoned mines. The State of Pennsylvania enacted a strong new mine drainage control law in 1966. West Virginia enacted in March, 1967, a new strip mine control law which has been described as very strict. The West Virginia legislature also enacted in March, 1967, certain amendments to the State Water Pollution Control Law which are intended to make the law easier to enforce. Federal grants-in-aid under Public Law 660, have probably been the greatest single factor contributing to increased construction of municipal waste treatment facilities in the basin. Although industrial waste treatment has not matched the rate of municipal treatment plant construction, the problems are admittedly more difficult to solve. The outlook is good for increased activity in the construction of industrial waste treatment facilities.

The industrialized section begins at Pittsburgh and extends south to Allenport at river mile 46. The next industrial region of any magnitude is at Morgantown, West Virginia. The entire river and most all of its tributaries are affected by acid mine drainage or other mine related activities. This basin contains the largest deposits of bituminous coal in the world.

The Monongahela River is navigable for its entire length. This is made possible through a series of locks and dams built and operated by the Corps of Engineers. Some of the tributary streams contain multi-purpose reservoirs. These provide flood control, low flow augmentation for waste dilution and navigation, and recreation.

The major tributary of the Monongahela River is the Youghiogheny River. This stream has similar problems due to municipal, industrial and acid mine wastes. Its headwaters arise in West Virginia and flow through Maryland into Pennsylvania. A portion of the Youghiogheny River is protected under the "Wild Rivers Act". This section has excellent "White Water" which is only suitable for rubber rafts, kayaks, and canoes.

The Monongahela River is formed by the junction of the Tygart River and the West Fork Rivers. Both of these streams are affected over their entire lengths by acid mine drainage; they have local problem areas with industrial and municipal wastes.

Even with these waste problems, these rivers are used as sources of potable water and sections are used for boating. There is some fishing, but few species abound waters affected by acid mine drainage.

There are plans under way to provide additional multi-purpose dams in the upstream portions of some of the Monongahela Rivers tributary streams. This will aid in providing additional dilution waters. However, the first order of business is still the effective solution to the acid mine drainage problems.

The section of these streams in the Greater Pittsburgh area drain rolling hills which have many towns and industrial plants, with some wooded areas and farms. However, the headwater regions drain some of the more beautiful country of the nation. The area is mountainous and forest covered. The elevations are steep in the river valley to enhance their beauty.

Allegheny River

The Allegheny River is one of the streams of which portions shall be protected to place it in the "Wild Rivers" Act.

Up stream of the navigable section, the number of islands and sandbars increase. The water is very shallow with vegetation growths on stream bottom. Only canoes can navigate certain portions of this stream. In addition to the navigation dams which extend up about half the length of the stream, there are several multi-purpose dams. These provide flood control, low/flow augmentation for waste dilution and navigation, and recreation. These dams are all on tributary streams except the newest one called Allegheny Reservoir which is on the main stream at the Pennsylvania-New York State Line.

Within the Allegheny River Basin, the four major sources of water pollution result from improperly treated domestic wastes, industrial wastes, brine wastes from oil and gas exploration, and acid drainage from active and inactive coal mining operations. The water uses to be protected are those of navigation, recreation, domestic and industrial waters, agricultural uses for fish, aquatic life, general aesthetics, and property values.

Several municipalities within the Allegheny River Basin presently provide no treatment for their sanitary wastes prior to discharge. All of these municipalities are under orders to do so. Some municipalities within the basin are presently providing inadequate domestic waste treatment. Industries which are discharging wastes include oil refining, pulp and paper, steel, tanneries, and organic dyes producers.

A water quality problem which has received minor attention is the untreated waste discharge from tow boats and larger private boats. There have been many fish kills as the result of acid mine drainage in the Allegheny and its tributaries. Much effort by the State of Pennsylvania has been devoted to cleaning up and controlling these acid mine discharges. Acid mine drainage interferes with the standard test for BOD. A standard procedure for the BOD analysis of water polluted by acid mine drainage should be developed.

The State of Pennsylvania recognizes that acid drainage from active and inactive coal mining operations is the single most important pollution control problem in the state. A major step in the control of acid drainage was taken by Pennsylvania in the passage of amendment to the

Clean Streams Law in January, 1966, which classified drainage from active coal mining operations as an industrial waste. All industrial waste discharges must be approved by a permit from the Sanitary Water Board of Pennsylvania. The Board has placed the following restrictions on discharges from active coal mining operations:

They should have zero acidity and some alkalinity with a pH between 6 to 9 and the maximum total iron concentration should not exceed 7.0 mg/liter.

The coal industry was given one year from the passage of the act to submit applications for permits approving the proposed drainage and waste disposal plan.

The State of Pennsylvania has been active in field source investigations and demonstration projects with respect to the problems of acid mine drainage. The most recent agreement was made between the State and the FWPCA for cooperative source investigations in the major acid mine drainage problem areas within the Allegheny River Basin.

There are several reaches of interstate and intrastate streams within the Allegheny River Basin which have water quality problems. In the Pittsburgh region, there is some industrial pollution. There are spots of pollution in the Ford City, Kittanning, Oil City, and Franklin areas. Many of the tributaries are affected by acid mine drainages.

The Kiskiminetas River is the chief tributary of the Allegheny River. It is very badly polluted by acid mine drainage through its length and most of its tributaries. It is not uncommon to have pH values of 2.5 and very rarely does it ever reach 5.5. There are also industrial wastes which enter the Kiskiminetas in the Johnstown region.

Interstate Water Quality Standards

Ohio River

Main Stem Between the States of Kentucky and Illinois from River Mile 848 to its Mouth at River Mile 981.

Kentucky

Interstate Water Quality Standards for all Streams are as follows:

Minimum Conditions Applicable to all Waters Here Considered at all Places and at all Times:

Regardless of the stream use classifications which follow for specific use, the following minimum conditions shall apply to that portion of the rivers which are a part of this report.

Free from substances attributable to municipal, industrial or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits.

Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial or other discharges in amounts sufficient to be unsightly or deleterious.

Free from materials attributable to municipal, industrial or other discharges producing color, odor or other conditions in such degree as to create a nuisance.

Free from substances attributable to municipal, industrial or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

Public Water Supply

Bacteria - Coliform group not to exceed 5,000 per 100 ml as a monthly arithmatical average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than five percent of such samples.

Threshold Odor Number - After normal treatment to be less than 3, generally the value will be less than 24 in the raw water.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time. (Values of specific conductance of 800 and 1,200 micromhos/cm (at 25°C.) may be considered equivalent to dissolved solids concentrations of 500 and 750 mg/l.)

Radioactive Substances - Gross beta activity (in the known absence of Strontium-90 and alpha emitters) not to exceed 1,000 micromicrocuries per liter at any time.

Chemical Constituents - Not to exceed the following specified concentrations at any time:

Constituent	Concentration mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Cyanide	0.2
Fluoride	1.0
Lead	0.05
Selenium	0.01
Silver	0.05

Industrial Water Supply

pH - Not less than 5.0 nor greater than 9.0 at any time.

Temperature - Not to exceed 95°F at any time.

Dissolved Solids - Not to exceed 750 mg/l as a monthly average value nor exceed 1,000 mg/l at any time. (Values of specific conductance of 1,200 and 1,600 micromhos/cm (at 25°C.) may be considered equivalent to dissolved solids concentrations of 750 and 1,000 mg/l.)

Aquatic Life

Dissolved Oxygen - Not less than 5.0 mg/l during at least 15 hours of any 24 hour period, nor less than 3.0 mg/l at any time.

pH - No values below 5.0 nor above 9.0 and preferably between 6.5 and 8.5.

Temperature - Not to exceed 93°F at any time during the months of May through November, and not to exceed 73°F at any time during the months of December through April.

Toxic Substances - Not to exceed one-tenth of the 48 hour median tolerance limit, except that other limiting concentrations may be used in specific cases when justified on the basis of available evidence and approved by the appropriate regulatory agency.

Recreation

Bacteria - Coliform group not to exceed 1,000 per 100 ml as a monthly arithmatical average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 2,400 per ml (either MPN or MF count) on any day.

Agricultural - Crop Use

Sodium Adsorption Ratio (SAR) - Will be less than 10 for agricultural uses.

Total Dissolved Solids - Will be less than 1,000 and preferably under 500 ppm.

Agricultural - Livestock Use

Chemical Constituents - The following values shall not be exceeded:

Constituent	Concentration mg/l
Nitrates	45.0
Arsenic	0.05
Chloride	250
Fluoride	1.0
Barium	1.0
Sulfate	250

Illinois

Interstate Water Quality Standards for the Main Stem of the Ohio River.

Public Water Supply and Food Processing Industry

Bacteria - Coliform group not to exceed 5,000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5 percent of such samples.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; nor exceed 750 mg/l at any time.

Radioactive Substances - Gross beta activity (in the known absence of strontium -90 and alpha emitters) not to exceed 1,000 micro-microcuries per liter at any time.

Chemical Constituents: Not to exceed:

Constituent	Concentration mg/l
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.025
Fluoride	1.00
Lead	0.05
Selenium	0.01
Silver	0.05

Aquatic Life Sectors

pH - No values below 6.0 nor above 9.0, and daily average preferably between 6.5 and 8.5.

Dissolved Oxygen - Not less than 5.0 mg/l during at least 16 hours at any 24 hour period, nor less than 3.0 mg/l at any time.

Temperature - Not to exceed 93°F at any time during the months of May - November and not to exceed 73°F at any time during December to April.

Toxic Substances - Not to exceed 1/10 of the 48 hour median tolerance limit.

Taste and Odor - Waters shall be free of substances from other than natural origin and will result in impairment of taste, odor, or other factors which would reduce the acceptability of fishes for human consumption.

Recreation Sector

Bacteria - Number per 100 ml by MF Techniques.

Number of bacteria shall be the arithmetic average of the last 5 consecutive samples.

Satisfactory area if MF coliform are less than 1,000 and MF fecal streptococci are less than 100.

Satisfactory area if MF coliforms are from 1,000 to 5,000 and MF fecal streptococci are less than 20.

A single sample result of over 100,000 coliforms shall require immediate investigation as to the cause.

Industrial Water Supply Sector

pH - Not less than 6.0 nor greater than 9.0 at any time.

Dissolved Oxygen - Not less than 3.0 mg/l during at least 16 hours of any 24 hour period, nor less than 2.0 mg/l at any time.

Temperature - Not to exceed 95°F at any time.

Dissolved Solids - Not to exceed 750 mg/l as a monthly average value, nor exceed 1,000 mg/l at any time.

Ohio River

Main Stem Between the States of Kentucky and Indiana from River Mile 491 to 848.

Kentucky

Interstate Water Quality Standards are found in pages 195 to 198 of this report.

Indiana

Interstate Water Quality Standards are as follows:

Minimum Conditions Applicable to all Waters at All Places and at all Times:

Free from substances attributable to municipal, industrial, agricultural or other discharges that will settle to form putrescent or otherwise objectionable deposits.

Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial, agricultural or other discharges in amounts sufficient to be unsightly or deleterious.

Free from materials attributable to municipal, industrial, agricultural or other discharges producing color, odor or other conditions in such degree as to create a nuisance.

Free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

For Public Water Supply and Food Processing Industry

Bacteria - Coliform group not to exceed 5,000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than five percent of such samples.

Threshold Odor Number - Taste and odor producing substances, other than naturally occurring, shall not interfere with the production of a finished water by conventional treatment consisting of coagulation, sedimentation, filtration and chlorination. The threshold odor number of the finished water must be three or less.

Dissolved Solids - Other than from naturally occurring sources not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time. Values of specific conductance of 800 and 1,200 micromhos/cm (at 25°C.) may be considered equivalent to dissolved solids concentrations of 500 and 750 mg/l.

Radioactive Substances - Gross beta activity (in the known absence of Strontium-90 and alpha emitters) not to exceed 1,000 picocuries per liter at any time.

Chemical Constituents - Not to exceed the following specified concentrations at any time:

Constituent	Concentration mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Cyanide	0.025
Fluoride	1.0
Lead	0.05
Selenium	0.01
Silver	0.05

For Industrial Water Supply

Dissolved Oxygen - Not less than 2.0 mg/l as a daily average value, nor less than 1.0 mg/l at any time.

pH - Not less than 5.0 nor greater than 9.0 at any time.

Temperature - Not to exceed 95°F at any time.

Dissolved Solids - Other than from naturally occurring sources not to exceed 750 mg/l as a monthly average value, nor exceed 1,000 mg/l at any time. Values of specific conductance of 1,200 and 1,600 micromhos/cm (at 25°C.) may be considered equivalent to dissolved solids concentrations of 750 and 1,000 mg/l.

For Aquatic Life

Dissolved Oxygen - Not less than 5.0 mg/l during at least 16 hours of any 24 hour period, nor less than 3.0 mg/l at any time.

pH - No values below 6.0 nor above 9.0 and daily average (or median) values preferably between 6.5 and 8.5.

Temperature - Not to exceed 93°F at any time during the months of April through November, and not to exceed 60°F at any time during the months of December through March.

Toxic Substances - Not to exceed one-tenth of the 96 hour median tolerance limit obtained from continuous flow bioassays where the dilution water and toxicant are continuously renewed, except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate regulatory agencies.

Taste and Odor - There shall be no substances which impart unpalatable flavor to food fish, or result in noticeable offensive odors in the vicinity of the water.

Trout Streams - In addition, the following criteria are applicable to those waters designated for put-and-take trout fishing:

Dissolved Oxygen - Not less than 6.0 mg/l as a daily average value, nor less than 4.0 mg/l at any time.

pH - Not less than 6.5 nor greater than 8.5 at any time.

Temperature - Not to exceed 65°F. (However, slightly higher temperatures may be tolerated with higher dissolved oxygen content than specified.)

For Recreation

Whole Body Contact - Coliform group not to exceed 1,000 per 100 ml as a monthly average value (either MPN or MF count) during any month of the recreational season; nor exceed this number in more than 20 percent of the samples examined during any month of the recreational season; nor exceed 2,400 per 100 ml (either MPN or MF count) on any day during the recreational season. The months of April through October, inclusive, are designated as the recreational season.

Partial Body Contact - Coliform group not to exceed 5,000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than five percent of such samples.

For Agricultural or Stock Watering

Criteria are the same as those shown for minimum conditions applicable to all waters at all places and at all times.

Ohio River

Main Stem Between the States of Ohio and Kentucky from River Mile 317 to 491.

Ohio

Interstate Water Quality Standards for this Section will be found on pages 206 to 208 of this report.

Kentucky

Interstate Water Quality Standards for this Section will be found on pages 195 to 198 of this report.

Ohio River

At the Pennsylvania-Ohio-West Virginia State Border.

Pennsylvania

Interstate Water Quality Standards for the mouth of the Ohio River to the Pennsylvania State Border.

pH - Not less than 6.0; not to exceed 8.5.

Dissolved Oxygen - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.

Iron - Total Iron - Not to exceed 1.5 mg/l.

Temperature - Not to exceed 5°F rise above ambient temperature or a maximum of 87°F, whichever is less; not to be changed by more than 2°F during any one hour period.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.

Bacteria (Coliforms/100 ml) - For the period 5/15 - 9/15 of any year; not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample.

Threshold Odor Number - Not to exceed 24 at 60°C.

Total Manganese - Not to exceed 1.0 mg/l.

Fluoride - Not to exceed 1.0 mg/l.

Phenol - Not to exceed .005 mg/l.

West Virginia

Interstate Water Quality Standards for the Main Stem of the Ohio River from the Ohio-Pennsylvania-West Virginia State Border to the Ohio-Kentucky-West Virginia State Border.

pH - No values below 5.5 nor above 9.0, and daily average (or median) values preferably between 6.5 and 8.5.

Dissolved Oxygen - Not less than 5.0 mg/l during at least 16 hours of any 24 hour period, nor less than 3.0 mg/l at any time.

Temperature - Not to exceed 93°F at any time during the months of May through November, and not to exceed 73°F at any time during months of December through April.

Threshold Odor - Not to exceed 24 (at 60°C as a daily average).

Toxic Substances - Not to exceed 1/10 of the 48 hour median tolerance limit, except that other limiting concentrations may be used in specific cases when justified on the basis of available evidence and approved by the appropriate regulatory agency.

Bacteria - The coliform group is not to exceed 1,000 per 100 ml as a monthly average value; nor exceed this number in 20 percent of the samples examined during any month; nor exceed 2,400 per ml on any day.

Radioactivity - Gross beta activity not to exceed 1,000 picocuries per liter (pCi/l) nor shall activity from dissolved strontium 90 exceed 10 pCi/l, nor shall activity from dissolved alpha emitters exceed 3 pCi/l.

Heavy Metals - Not to exceed:

Constituents	Concentration mg/l
Arsenic	0.01
Barium	0.50
Cadmium	0.01
Chromium (Hexavalent)	0.05
Lead	0.05
Silver	0.05

Other Compounds:

Constituents	Concentration mg/l
Nitrates	45.0
Phenol	0.001
Cyanide	0.025
Fluoride	1.000
Selenium	0.010

Ohio

Interstate Water Quality Standards for the entire reach of the Main Stem of the Ohio River.

Minimum Conditions Applicable to all Waters at all Places and at all Times:

Free from substances attributable to municipal, industrial or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits;

Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial or other discharges in amounts sufficient to be unsightly or deleterious;

Free from materials attributable to municipal, industrial, or other discharges producing color, odor or other conditions in such degree as to create a nuisance;

Free from substances attributable to municipal, industrial or other discharges in concentrations or combinations which are toxic or harmful to human, animal or aquatic life.

For Public Water Supply

Bacteria - Coliform group not to exceed 5,000 per 100 ml as a monthly average value; nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5 percent of such samples.

Threshold Odor Number - Not to exceed 24 (at 60°C) as a daily average.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time.

Radioactivity - Gross beta activity not to exceed 1,000 picocuries per liter (pCi/l) nor shall activity from dissolved strontium -90 exceed 10 pCi/l, nor shall activity from dissolved alpha emitters exceed 3 pCi/l.

Chemical Constituents - Not to exceed at any time.

Constituents	Concentration mg/l
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.025
Fluoride	1.00
Lead	0.05
Selenium	0.01
Silver	0.05

For Industrial Water Supply

pH - Not less than 5.0 nor greater than 9.0 at any time.

Dissolved Oxygen - Not less than 2.0 mg/l as a daily average value, nor less than 1.0 mg/l at any time.

Temperature - Not to exceed 95°F at any time.

Dissolved Solids - Not to exceed 750 mg/l as a monthly average value, nor exceed 1000 mg/l at any time.

For Aquatic Life

pH - No values below 5.0 nor above 9.0, and daily average values preferably between 6.5 and 8.5.

Dissolved Oxygen - Not less than 5.0 mg/l during at least 16 hours of any 24 hour period, nor less than 3.0 mg/l at any time.

Temperature - Not to exceed 93°F at any time during the months of May through November, and not to exceed 73°F at any time during the months of December through April.

Toxic Substances - Not to exceed one tenth of the 48 hour median tolerance limit.

For Recreation

Bacteria - Coliform group not to exceed 1,000 per 100 ml as a monthly average value; nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 2,400 per 100 ml on any day.

Tennessee River

At the Kentucky-Tennessee State Line.

Kentucky

Interstate Water Quality Standards for the Tennessee River from its mouth to the Kentucky-Tennessee State Line are the same as those for the Ohio River which can be found on pages 206 to 208 of this report.

Tennessee

Interstate Water Quality Standards for the Tennessee River from River Mile 49.3 at the Kentucky-Tennessee State Line to River Mile 215.2.

Base Parameters

pH - 6.5 - 8.5.

Dissolved Oxygen - 5.0 mg/l.

Temperature - 93°F.

Total Dissolved Solids - 500 mg/l.

Coliform Group - 10,000 per 100 ml.

Fecal Coliform - 1,000 per 100 ml.

Domestic Raw Water Supply

Dissolved Oxygen - There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.

pH - The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

Hardness or Mineral Compounds - There shall be no substances added to the waters that will increase the hardness or mineral content of the waters to such an extent to appreciably impair the usefulness of the water as a source of domestic water supply.

Total Dissolved Solids - The total dissolved solids shall at no time exceed 500 mg/l.

Solids, Floating Materials and Deposits - There shall be no distinctly visible solids, scum, foam, oily slick, or the formation of slimes, bottom deposits or sludge banks of such size or character as may impair the usefulness of the water as a source of domestic water supply.

Turbidity or Color - There shall be no turbidity or color added in amounts or characteristics that cannot be reduced to acceptable concentrations by conventional water treatment processes.

Temperature - The temperature of the water shall not exceed 93°F and the maximum rate of change shall not exceed 3°F per hour.

Microbiological Coliform - Coliform group shall not exceed 10,000 per 100 ml. as a monthly average value (either MPN or MF count); nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml. in more than five percent of such samples. These values may be exceeded provided the organisms are known to be of nonfecal origin. No disease producing bacteria or other objectionable organisms shall be added to surface waters which will result in the contamination of said waters to such an extent as to render the water unsuitable as sources of domestic water supply after conventional water treatment.

Taste or Odor - There shall be no substances added which will result in taste or odor that prevent the production of potable water by conventional water treatment processes.

Toxic Substances - There shall be no toxic substances added to the waters that will produce toxic conditions that materially affect man or animals or impair the safety of a conventionally treated water supply.

Other Pollutants - Other pollutants shall not be added to the water in quantities that may be detrimental to public health or impair the usefulness of the water as a source of domestic water supply.

Industrial Water Supply - All parameters are the same except that they refer to impairment of use as an industrial water supply. There is no standard for coliform.

Fish and Aquatic Life

Dissolved Oxygen - The dissolved oxygen shall be maintained at 5.0 mg/l except in limited sections of the stream receiving treated effluents. In these limited sections, a minimum of 3.0 mg/l dissolved oxygen shall be allowed. The dissolved oxygen content shall be measured at mid-depth in waters having a total depth of ten (10) feet or less and at a depth of five (5) feet in waters having a total depth of greater than ten (10) feet. A minimum dissolved oxygen content of 6.0 mg/l shall be maintained in recognized trout streams.

pH - The pH value shall lie within the range of 6.5 to 8.5 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

Other Parameters - Are all the same as listed for a domestic water supply, except the wording refers to fish and aquatic life.

Recreation

Temperature - The temperature of the water shall not exceed 93°F.

Microbiological Coliform - The fecal coliform group shall not exceed 5,000 per 100 ml. as a monthly average value nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml. in more than five percent of such samples. In those waters that are physically suitable and available to the public for water-contact recreation the fecal coliform concentration shall not exceed 1,000 per 100 ml. in any two consecutive samples collected during the months of May through September. Water areas near outfalls of domestic sewage treatment plants are not considered suitable for water-contact recreation.

Other Parameters - Are all the same as used for domestic water supply, except the wording substitutes recreation. There is also no standard listed for hardness.

Irrigation

Temperature - The temperature of the water shall not be raised or lowered to such an extent as to interfere with its use for irrigation purposes.

Other Parameters - Are all the same as listed for domestic water supply with the wording substituted for irrigation. There are no standards listed for Total Dissolved Solids, Turbidity, Coliform, or Taste and Odor.

Livestock Watering and Wildlife - Are the same as those for irrigation except the wording changed to livestock, etc.

Navigation - Are the same as those for irrigation with the wording changed to navigation. There is not a standard for pH.

Tennessee River

At River Mile 215 where the State Lines of Mississippi, Alabama, and Tennessee intersect.

Tennessee

Interstate Water Quality Standards for this location are listed on pages 208 to 211 of this report.

Alabama

Interstate Water Quality Standards for the Tennessee River from the Alabama-Tennessee-Mississippi State Line to the Lower End of Seven Mile Island at River Mile 247.

Public Water Supply

pH - Should not deviate more than one unit from normal pH nor be less than 6.0 nor greater than 8.5.

Temperature - The ambient temperature of receiving waters shall not be increased by more than 10 percent nor shall the temperature of the receiving waters exceed 90°F except that the temperature may be as high as 93°F for not more than 8 hours during any 24 hour period.

Dissolved Oxygen - Shall not be less than 4.0 mg/l at a depth of five feet in waters ten feet or greater in depth and at mid-depth in waters less than 10 feet in depth.

Bacteria - Bacteria of the fecal coliform group not to exceed 5,000 per 100 ml as a monthly average value nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5 percent of the samples examined during one month.

Swimming and Body Water Contact Sports

Bacteria - Bacteria of the fecal coliform group not to exceed 1,000 per 100 as a monthly average value during the months of May through September, nor exceed this value in any two consecutive samples collected during these months.

Other Parameters - The Standards for pH, temperature, and dissolved oxygen are the same as for a Public Water Supply.

Shellfish Harvesting, Fish and Wildlife

Toxic Substances - Only such amounts that will not exceed 1/10th of the 48 hour median tolerance limit.

Other Parameters - The Standards for pH, temperature, and dissolved oxygen are the same as for Public Water Supply.

Mississippi

Interstate Water Quality Standards for the Tennessee River at the Mississippi-Alabama-Tennessee State Line.

Free from substances attributable to municipal, industrial, agricultural or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits.

Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial, agricultural or other discharges in amounts sufficient to be unsightly or deleterious.

Free from materials attributable to municipal, industrial, agricultural or other discharges producing color, odor, or other conditions in such degree as to create a nuisance.

Free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to humans, animal or aquatic life.

Municipal wastes, industrial wastes, or other wastes shall receive effective treatment or control (secondary or equivalent) in accordance with the latest practical technological advances and shall be approved by the Commission. A degree of treatment greater than secondary will be required when necessary to protect legitimate water uses.

Public Water Supply

Dissolved Oxygen - There shall be no oxygen demanding substances added which will depress the D.O. content below 4.0 mg/l.

pH - The pH shall not be caused to vary more than 1.0 unit above or below normal pH of the waters and lower value shall be not less than 6.0 and upper value not more than 8.5.

Temperature - Shall not be increased more than ten degrees F (10°F) above the natural prevailing background temperatures, nor exceed a maximum of 93°F after reasonable mixing.

Bacteria - Fecal coliform not to exceed 5,000 per 100 ml. as a monthly average value (either MPN or MF count); nor to exceed this number in more than twenty percent (20%) of the samples examined during any month; nor to exceed 20,000 per 100 ml. in more than five percent (5%) of such samples.

Chlorides - There shall be no substances added which will cause the chloride content to exceed 250 mg/l in fresh water streams.

Specific Conductance - There shall be no substances added to the waters to cause the dissolved solids to exceed 500 micromhos/cm for fresh water streams.

Dissolved Solids - There shall be no substances added to the waters to cause the dissolved solids to exceed 500 mg/l.

Threshold Odor - There shall be no substances added which will cause the threshold odor number to exceed 24 (at 60°C) as a daily average.

Phenolic Compounds - There shall be no substances added which will cause the phenolic content to be greater than 0.001 mg/l (phenol).

Radioactive Substances - There shall be no radioactive substances added to the waters which will cause the gross beta activity (in the known absence of Strontium-90 and alpha emitters) to exceed 1,000 micromicrocuries at any time.

Chemical Constituents - Not to exceed the following concentrations at any time:

Constituent	Concentration mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (hexavalent)	0.05
Cyanide	0.2
Fluoride	0.7 - 1.2
Lead	0.05
Selenium	0.01
Silver	0.05

Tennessee River

At the Tennessee-Alabama State Line at River Mile 416.5.

Alabama

Interstate Water Quality Standards for this Section from Roseberry Creek (River Mile 382.5) to the Alabama-Tennessee

State Line (River Mile 416.5) are the same as those found on pages 211 to 212 of this report.

Tennessee

Interstate Water Quality Standards for this Section at the Alabama-Tennessee State Line (River Mile 416.5) to the confluence of the French Broad and the Holston Rivers (River Mile 652) are the same as those found on pages 208 to 211 of this report.

Wabash River

Between the Borders of Indiana and Illinois from its mouth.

Illinois

Interstate Water Quality Standards for the Wabash River are the same as those for the Ohio River as found on pages 198 to 200 of this report.

Indiana

Interstate Water Quality Standards for the Wabash River are the same as those for the Ohio River as found on pages 200 to 203 of this report.

Wabash River

At the Indiana-Ohio State Line.

Indiana

Interstate Water Quality Standards for the Upper Wabash River at the Ohio-Indiana State Line are the same as those found on pages 200 to 203 of this report.

Ohio

Interstate Water Quality Standards for the Upper Wabash River at the Ohio-Indiana State Line are similar to those found on pages 206 to 208 of this report.

Kanawha River

Near its mouth as it enters the Ohio River.

West Virginia

Interstate Water Quality Standards for the Section of the Kanawha River from its mouth to River Mile 72.

Dissolved Oxygen - Not less than 3 mg/l at any time.

pH - Values normal for the waters in the area in questions, however, generally held between 6.0 and 8.5.

Temperature - Not to exceed 93°F in any case or 10°F above ambient stream temperature, whichever is limiting.

Threshold Odor - Threshold odor not to exceed a threshold odor number of 64 at 60°C as a daily average.

Toxic Substances - Not to exceed 1/10 of the 48 hour median tolerance limit.

Bacteria - The coliform group is not to exceed 5,000 per 100 ml as a monthly average nor exceed this number in more than 20 percent of the samples examined during the month; nor exceed 20,000 per 100 ml in more than 5 percent of the samples.

Radioactivity - Gross beta activity not to exceed 1,000 picocuries per liter (pCi/l) nor shall activity from dissolved strontium-90 exceed 10 pCi/l nor shall activity from dissolved alpha emitters exceed 3 pCi/l.

Heavy Metals - Not to exceed the following, regardless of flow:

Constituent	Concentration mg/l
Arsenic	0.01
Barium	0.50
Cadmium	0.01
Chromium (hexavalent)	0.05
Lead	0.05
Silver	0.05

Other Compounds

Constituent	Concentration mg/l
Nitrates	45
Chloride	200
Sulfate	200
Phenol	0.001
Cyanide	0.025
Fluoride	1.0
Selenium	0.01

Allegheny River

Near Pittsburgh, Pennsylvania.

Pennsylvania

Interstate Water Quality Standards for the Allegheny River from its mouth to the Kiskiminetas River.

pH - Not less than 6.0: not to exceed 8.5.

Dissolved Oxygen - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.

Iron - Total iron - Not to exceed 1.5 mg/l.

Temperature - Not to exceed 5.0 F rise above ambient temperature or a maximum of 87°F, whichever is less: not to be changed by more than 2°F during any one hour period.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value: not to exceed 750 mg/l at any time.

Bacteria (Coliform/100 ml) - For the period 5/15-9/15 of any year: not to exceed 1000/100 ml as arithmatic average value: not to exceed 1000/100 ml in more than two consecutive samples: not to exceed 2400/100 ml in more than one sample.

Threshold Odor No. - Not to exceed 24 at 60°C.

Total Manganese - Not to exceed 1.0 mg/l.

Allegheny River

At the Pennsylvania-New York State Border near the Allegheny Reservoir.

Pennsylvania

Interstate Water Quality Standards for the Allegheny River between Redbank Creek and the Pennsylvania-New York State Line.

pH - Not less than 6.0; not to exceed 8.5.

D.O. - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.

Iron - Total Iron - Not to exceed 1.5 mg/l.

Temperature - Not to exceed 5°F rise above ambient temperature or a maximum of 87°F, whichever is less; not to be changed by more than 2°F during any one hour period.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.

Bacteria - For the period 5/15 - 9/15 of any year; not to exceed 1000/100 ml as an arithmetic average value, not to exceed 1000/100 ml in more than two consecutive samples; not to exceed 2400/100 ml in more than one sample.

Threshold Odor Number - Not to exceed 24 at 60°C.

Methylene Blue Active Substance - Not to exceed 0.5 mg/l.

Chlorides - Not to exceed 150 mg/l.

New York

Interstate Water Quality Standards for the Allegheny River from the Pennsylvania-New York State Line to Tributary No. 9 in New York. State.

Floating Solids; Settleable Solids; Sludge Deposits - None which are readily visible and attributable to sewage, industrial waste, or other wastes or which deleteriously increase the amounts of these constitutents in receiving waters after opportunity for reasonable dilution and mixture with the waste discharged thereto.

Sewage or Waste Effluents - None which are not effectively disinfected.

pH - Range between 6.5 and 8.5.

Dissolved Oxygen - For trout waters, not less than 5.0 ppm: for non-trout waters not less than 4.0 ppm.

Toxic Wastes, Oil, Deleterious Substances, Colored or Other Wastes, or Heated Liquids - None alone or in combination with other substances or wastes in sufficient amount at such temperature as to be injurious to fish life, make the waters unsafe or unsuitable for bathing or impairing the water for any other best usage as determined for the specific waters which are assigned to this class.

With reference to certain toxic substances in affecting fish life, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters, which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, based on non-trout waters of approximately medium alkalinity (80 ppm) or above for the State, in which groups most of the waters near industrial areas in this state will fall, and without considering or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standard for this type of water. Waters of lower alkalinity must be specifically considered since the toxicity effect of most pollutants will be greatly increased.

Ammonia or ammonium compounds - Not greater than 2.0 ppm (NH_3) at pH of 8.0 or above.

Cyanide - Not greater than 0.1 ppm (CN).

Ferro or Ferrocyanide - Not greater than 0.4 ppm ($Fe(CN)_6$).

Copper - Not greater than 0.2 ppm (Cu).

Zinc - Not greater than 0.3 ppm (Zn).

Cadmium - Not greater than 0.3 ppm (Cd).

Allegheny River

At the Pennsylvania-New York State Border Near Portville, New York.

New York

Interstate Water Quality Standards for Allegheny River from Tributary No. 43 in N.Y. to the New York-Pennsylvania Border.

Water Use - Fishing recreation.

Floating Solids, Settleable Solids; Sludge Deposits - None which are visible and attributable to sewage, industrial wastes or which deleteriously increase the amounts of these constituents in receiving waters after opportunity for reasonable dilution and mixture with the wastes discharged thereto.

pH - Range between 6.5 and 8.5.

Dissolved Oxygen - For trout waters, not less than 5.0 ppm; for non-trout waters, not less than 4.0 ppm.

Toxic Wastes, Oil, Deleterious Substances, Colored or Other Wastes, or Heated Liquids - Not alone or in combination with other substances or wastes in sufficient amount at such temperature as to be injurious to fish life, make the waters unsafe or unsuitable for bathing or impairing the water for any other best usage as determined for the specific waters which are assigned to this class.

With reference to certain toxic substances in affecting fish life, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters, which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, based on non-trout waters of approximately medium alkalinity (80 ppm) or above for the State, in which groups most of the waters near industrial areas in this state will fall, and without considering or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standard for this type of water. Waters of lower alkalinity must be specifically considered since the toxicity effect of most pollutants will be greatly increased.

Ammonia or ammonium compounds - Not greater than 2.0 ppm (NH_3) at pH of 8.0 or above.

Cyanide - Not greater than 0.1 ppm (CN).

Ferro or Ferrocyanide - Not greater than 0.4 ppm ($Fe(CN)_6$).

Copper - Not greater than 0.2 ppm (Cu).

Zinc - Not greater than 0.3 ppm (Zn).

Cadmium - Not greater than 0.3 ppm (Cd).

Pennsylvania

Interstate Standards for Allegheny River from the Pennsylvania-New York Border to its source. Zone 08.040.

pH - Not less than 6.0; not to exceed 8.5.

Dissolved Oxygen - Minimum daily average 6.0 mg/l; no value less than 5.0 mg/l.

Iron - Total Iron - Not to exceed 1.5 mg/l.

Temperature - Not to be increased by more than 5.0 F above natural temperatures; not to be increased above 58°F.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.

Bacteria (Coliform/100 ml) - For the period 5/15-9/15 of any one year; not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample.

Threshold Odor Number - Not to exceed 24 at 60°C.

Methylene Blue Active Substance (MBAS) - Not to exceed 0.5 mg/l.

Chlorides - Not to exceed 150 mg/l.

Monongahela River

At the Pennsylvania-West Virginia State Border.

Pennsylvania

Interstate Water Quality Standards from its mouth to the Pennsylvania-West Virginia State Border.

pH - Not less than 6.0; not to exceed 8.5.

Dissolved Oxygen - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.

Iron - Total Iron - Not to exceed 1.5 mg/l.

Temperature - Not to exceed 5°F rise above ambient temperature or a maximum of 87°F, whichever is less; not to be changed by more than 2°F during any one hour period.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; nor to exceed 750 mg/l at any time.

Bacteria (Coliform/100 ml) - For the period 5/15 - 9/15 of any year; not to exceed 1000/100 ml as an arithmetic average value; not to exceed 1000/100 ml in more than two consecutive samples; not to exceed 2400/100 ml in more than one sample.

Threshold Odor Number - Not to exceed 24 at 60°C.

Total Manganese - Not to exceed 1.0 mg/l.

Phenol - Not to exceed .005 mg/l.

West Virginia

Interstate Water Quality Standards from the Pennsylvania-West Virginia State Border to the confluence of the Tygart Valley and the West Fork Rivers.

pH - Values normal for the waters of the area in question, however, generally held between 6 and 8.5.

Dissolved Oxygen - Not less than 5 mg/l at any time.

Temperature - Not to exceed 87°F at any time during the months of May through November and not to exceed 73°F at any time during the months of December through April.

Threshold Odor - Not to exceed a threshold odor number of 8 at 60°C as a daily average.

Toxic Substances - Not to exceed 1/10 of the 96 hour median tolerance limit.

Bacteria - The coliform group is not to exceed 1000 per 100 ml as a monthly average nor exceed this number in more than

20 percent of the samples examined during any month; nor exceed 2400 per 100 ml on any day.

Radioactivity - Gross beta activity not to exceed 1,000 picocuries per liter (pCi/l) nor shall activity from dissolved strontium - 90 exceed 10 pCi/l, nor shall activity from dissolved alpha emitters exceed 3 pCi/l.

Heavy Metals: Not to exceed the following:

Constituent	Concentration mg/l
Arsenic	0.01
Barium	0.50
Cadmium	0.01
Chromium (Hexavalent)	0.05
Lead	0.05
Silver	0.05

Other Compounds

Constituents	Concentration mg/l
Nitrates	45
Chlorides	100
Sulfates	200
Phenol	0.001
Cyanide	0.025
Fluoride	1.0
Selenium	0.01

Youghiogheny River

At the Maryland-Pennsylvania State Border.

Pennsylvania

Interstate Water Quality Standards from Youghiogheny Dam to Pennsylvania-Maryland State Border.

pH - Not less than 6.0; not to exceed 8.5.

Dissolved Oxygen - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.

Iron - Total Iron - Not to exceed 1.5 mg/l.

Temperature - Not to be increased by more than 5°F above natural temperatures nor to be increased above 58°F.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.

Bacteria (Coliform/100 ml) - For the period 5/15-9/15 of any year; not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample.

Maryland

Interstate Water Quality Standards for Youghiogheny River from the Maryland-Pennsylvania State Border to the Little Youghiogheny River.

pH - Not less than 6.0 nor greater than 8.5.

Dissolved Oxygen - Concentration must not be less than 5.0 mg/l at any time, with a minimum monthly average of not less than 6.0 mg/l.

Temperature - Temperature must not exceed 72°F at any time.

Bacteria - Fecal coliform organism density not to exceed 240 MPN per 100 ml.

Youghiogheny River

At the Maryland-West Virginia State Border.

West Virginia

Interstate Water Quality Standards for the Youghiogheny River from the Maryland-West Virginia State Border to the source.

Dissolved Oxygen - Not less than 5 mg/l at any time.

pH - 6.0 to 8.5.

Temperature - Not to exceed 87°F at any time during the months of May through November and not to exceed 73°F at any time during the months of December through April.

Threshold Odor - Threshold odor not to exceed a threshold odor number of 8 at 60°C as a daily average.

Toxic Substances - Not to exceed 1/10 of the 96 hour median tolerance limit.

Bacteria - The coliform group is not to exceed 5,000 per 100 ml as a monthly average nor exceed this number in more than 20 percent of the samples examined during the month; nor exceed 20,000 per 100 ml in more than 5 percent of the samples.

Radioactivity - Gross beta activity not to exceed 1000 picocuries per liter (pCi/l) nor shall activity from dissolved strontium 90 exceed 10 pCi/l, nor shall activity from dissolved alpha emitters exceed 3 pCi/l.

Heavy Metals

Constituents	Concentration mg/l
Arsenic	0.01
Barium	0.50
Cadmium	0.05
Chromium (Hexavalent)	0.05
Lead	0.05
Silver	0.05

Other Compounds

Constituents	Concentration mg/l
Nitrates	45
Chlorides	100
Sulfates	200
Phenol	0.001
Cyanide	0.025
Fluoride	1.000
Selenium	0.010

Maryland

Interstate Water Quality Standards for the Youghiogheny River from the Little Youghiogheny River to the Maryland-West Virginia State Border.

pH - Not less than 6.0 nor greater than 8.5.

Dissolved Oxygen - Concentration not less than 5.0 mg/l at any time, with a minimum monthly average of not less than 6.0 mg/l.

Temperature - Temperature must not exceed 72°F at any time.

Bacteria - Monthly average value (either MPN or MP count) of coliform organisms not to exceed 5,000 per 100 ml of sample; nor to exceed this number in more than 20% of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5% of such samples. Fecal coliform organism density should not exceed 240 MPN per 100 ml.

Cheat River

At the Pennsylvania-West Virginia State Line.

Pennsylvania

Interstate Water Quality Standards for the Cheat River from the mouth to the Pennsylvania-West Virginia State Line.

pH - Not less than 6.0; not to exceed 8.5.

Dissolved Oxygen - Minimum daily average 5.0 mg/l; no value less than 4.0 mg/l.

Iron - Total Iron - Not to exceed 1.5 mg/l.

Temperature - Not to exceed 5°F rise above ambient temperature or a maximum of 87°F whichever is less; not to be changed by more than 2°F during any one hour period.

Dissolved Solids - Not to exceed 500 mg/l as a monthly average value; not to exceed 750 mg/l at any time.

Bacteria (Coliforms/100 ml) - For the period 5/15-9/15 of any year; not to exceed 1,000/100 ml as an arithmetic average value; not to exceed 1,000/100 ml in more than two consecutive samples; not to exceed 2,400/100 ml in more than one sample.

West Virginia

Interstate Water Quality Standards for the Cheat River from the Pennsylvania-West Virginia State Line to its Source.

pH - 6.0 to 8.5.

Dissolved Oxygen - Not less than 5 mg/l at any time.

Temperature - Not to exceed 87°F at any time during the months of May through November and not to exceed 73°F at any time during the months of December through April.

Threshold Odor - Threshold odor not exceed a threshold odor number of 8 at 60°C as a daily average.

Toxic Substances - Not to exceed 1/10 of the 96 hour median tolerance limit.

Bacteria - The coliform group is not to exceed 1,000/100 ml as a monthly average value; nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 2,400 per 100 ml on any day.

Radioactivity - Gross beta activity not to exceed 1000 picocuries per liter (pCi/l) nor shall activity from dissolved alpha emitters exeecd 3 pci/l.

Heavy Metals - Not to exceed the following:

Constituent	Concentration mg/l
Arsenic	0.01
Barium	0.50
Cadmium	0.01
Chromium (Hexavalent)	0.05
Lead	0.05
Silver	0.05

Other Compounds

Constituent	Concentration mg/l
Nitrates	45
Chlorides	100
Sulfates	200
Phenol	0.001
Cyanide	0.025
Fluoride	1.000
Selenium	0.010

APPENDIX II - SOUTHEASTERN RIVER BASIN

River Basin Descriptions

Ochlockonee River

The Ochlockonee River drains part of southwest Georgia and the "Big Bend" portion of north Florida. The economy is a combination of agriculture and industry with slightly more farming. Land resources in Georgia are generally devoted to crops such as cotton, tobacco, fruits, and vegetables. Most of the land resources in Florida are used for forestry products. Industrial development is related to lumber and wood products and food processing. The balance of industrial endeavor is in textiles, apparel, and minerals. Pollution sources are generally localized from sewage discharges into the Ochlockonee River or its tributaries. In addition, there are several meat packing and rendering plants which cause pollution in the upper reaches of the Ochlockonee River in Georgia. Most of the water use is devoted to body contact sports and fishing; very little surface water is used for domestic supplies. High densities of fecal coliform, increased BOD, and depressed DO are common below Moultrie and Thomasville, Georgia. In the Moultrie area, most of the pollution comes from an open dump which receives garbage, rubbish, and dead animals. The dump is separated from the Ochlockonee River by a small drainage area. Wastes from a sewage treatment plant enter the river below the dump; increased organic and bacteriological pollution result. A packing company farther downstream also contributes to localized pollution. Industrial wastes on the reaches of the Ochlockonee River just over the state line from Cairo, Georgia, and Havana, Florida, apparently have no major effect on the stream below Thomasville, Georgia. Again, high coliform densities were observed. Occasional high chloride concentrations originate in a tributary known as Tired Creek, which apparently has a pickle plant. An automatic water monitor has been installed on the Ochlockonee River by the FWPCA. Data are collected by the Florida State Board of Health. This monitor is on Florida Highway 12, just over the Georgia-Florida state line and continuously monitors DO, temperature, pH, chloride, and conductivity. This monitor was installed in 1965 and since then no abnormal conditions have been reported. The Ochlockonee eventually runs into Lake Talquin, then is joined by Telogia Creek and flows through swampy land, and eventually empties into Apalachee Bay through the Ochlockonee Bay. Proposed multi-purpose impoundments on several reaches of the river will more than likely reduce any localized pollution. The effect of Lake Talquin as a holding and stabilizing basin is also evident, since DO levels are generally much higher below the lake than above. Other impoundments upstream will improve the water quality in the Cairo, Georgia area and the Tallahassee-Quincy, Florida area. A sanitary land fill project has been planned in the Moultrie, Georgia area to eliminate runoff from the open dump.

The Ochlockonee River is very dark in color. It drains an area which is heavily forested and has many swampy areas. Thus, there are considerable organic contributions such as lignins, tannins, and the variety of breakdown products they produce. These contribute to increased color and turbidity, increases in taste and odor problems, as well as oxygen depletion.

The stream is very shallow and meanders quite a lot. The slope is very shallow and the topography very flat. This region receives a large amount of rainfall and is subject to flooding and hurricanes. There is considerable debris in the stream along with fallen trees and brush. The stream deposits a quantity of dark, muddy water to the Ochlockonee Bay and later Apalachee Bay. In the bay area there are mud flats covered with tall grasses. The stream bottom is a white sand in contrast to its dark organic color.

Apalachicola River Basin

The Chattahoochee River, the Flint River and Spring Creek join together to form the Apalachicola River which drains into Apalachicola Bay and finally the Gulf of Mexico. All three of these streams have their origins in Northwestern Georgia. The Apalachicalla River is approximately 90 miles long, whereas the Chattahoochee River is some 600 miles long, and is one of the larger rivers of Georgia. The Chattahoochee River rises in the Blue Ridge Mountains of the Appalachian group. The Chattahoochee River is a potential source of water power and is navigable for small boats, as far as Columbus, Georgia. It drains an area used for agriculture and forest cover. The Flint River is approximately 285 miles in length, and is located primarily in the State of Georgia. The Flint River drains an area which receives rainfall in the amounts of 40 to 60 inches, and is predominantly an agricultural region. It is also a source of water power and is navigable by small boats up to Albany, Georgia.

This basin is located in north and west Georgia, east Alabama, and northwest Florida. The Chattahoochee and

Flint Rivers drain the northwest and west-central areas of Georgia and east Alabama. Both rivers flow into Lake Seminole which is located on the Georgia-Florida state line. Spring Creek drains an area between these two rivers and also enters Lake Seminole. The Apalachicola River flows from Lake Seminole at the Jim Woodruff Dam into and through Florida, then into Apalachicola Bay, which enters the Gulf of Mexico. Several impoundments in this basin aid in assimilation of wastes. Primary sources of waste in this basin are from the larger cities of Atlanta, Columbus, Albany, and Bainbridge, Georgia. Other sources are industrial, coming from airlines, auto plants, textiles and the fish meal industry. Wastes from the auto and airline plants are primarily chromates, cyanides, and residual acids. The general problem throughout the basin is again one of inadequate domestic waste treatment, which results in high BOD, low DC, and high coliform counts in the rivers. Oyster beds in the Apalchicola Bay area, which normally produce 70% of the annual harvest, have been closed periodically due to high coliform counts. Sizeable portions of the beds are closed permanently. Only one portion of the main stem of the Chattahoochee has few pollution problems. Several quality data stations have been established throughout the basin. Parameters measured are: flow, temperature, BOD, DO, and coliform bacteria. However, these sites seem to be quite appropriate and need only upgrading to include other vital parameters to serve as water quality stations.

The Apalachicola Bay contributes a muddy discharge which extends into the Gulf of Mexico for over two and one-half miles. The bay is patchy with some areas muddy and others green. There are mud flats in sections of the bay.

The Apalachicola River is very muddy with a medium dark brown color. It meanders through this flat country. The terrain is very flat. There are many oxbow cutoffs which have growths of algae. There are a few small farms but most of the land is tree covered.

The Flint River has a brownish-gray color near the mouth, however, at the headwaters it is more of a red color due to the soil in the region. In the headwaters, the stream is very shallow with rapids in some sections with large rocks and boulders in the stream. The Flint River has an impoundment in the headwaters region which is multi-purpose. The river is very small where it begins in the Atlanta region. There are industrial and municipal wastes in specific sections. However, the soil, farming and forest areas, contribute more to the overall quality of the stream.

Spring Creek drains a region between the Flint and Chattahoochee Rivers. Its mouth drains into Lake Seminole. Its importance as an interstate stream is that its drainage into Lake Seminole then passes across the Georgia-Florida state line. The stream drains an agricultural region, although the immediate area is tree covered along the banks of the stream. The soils are either sandy or are red in color. The stream is dark brown in one area and dark green in others.

The Chattahoochee River drains an area where the soil is very red in color which causes the turbidity and color of the stream to be high. It serves as the border between Alabama and Georgia for about half of their common border. The Chattahoochee River has five impounded areas which are multi-purpose and hydroelectric dams. The three closest to the mouth have locks for navigation. New construction within this basin contributes large amounts of sediment to the streams. There are industrial and municipal effluents which cause local pollution problems. However, the agriculture, forests, and soil tend to be the major values in controlling stream quality in this region.

Choctawhatchee River

The Choctawhatchee River rises in southeast Alabama and flows generally southward through Alabama and northwest Florida to empty into the Choctawhatchee Bay, an arm of the Gulf of Mexico. In the Alabama portion of the basin, there are several medium sized cities and some mining operations. The Florida portion of the basin has many larger cities and more diversified industry, including several pulp and paper mills and two chemical plants. In the Alabama area, sources of pollution are generally localized and consist of untreated or treated sewage discharges into intermittent streams. The aggregate of these wastes increases bacteriological counts below the Alabama-Florida state line. Industrial use of the water is limited to iron-ore washing and generation of electricity. Limited use is made of water for agricultural purposes. Most of the Alabama portion of the Choctawhatchee River is made available for fishing and, at its discharge point in the Choctawhatchee Bay, sport fishing is highly developed as is shellfish harvesting.

The river is a dark color with banks that are either red in color or sandy. The river becomes more turbid as it flows downstream. The area that it drains is mostly forested with some farming. There are a number of specific points where industrial waste treatment should be improved. The bay contains a delta with mud flats covered with grasses. The bay tends to hold back much of the sediment and silt which passes into it.

Yellow River

It has its headwaters in Southeastern Alabama. It flows southwest to cross into the Florida panhandle. It flows into Blackwater Bay and then to Pensacola Bay and finally to the Gulf. This region is heavily forested. The drainage is shallow, twisting and narrow. The water is dark brown in color due to the drainage areas high lignin and tannin wastes. These wastes have high oxygen demands. The mouth has a delta area with several channels. The discharge is turbid with mud. The bottom of the river is a white sand.

Data on the type of wastes discharged to the Yellow River are very sparse. The wastes presumably come from primary and secondary sewage treatment plants of nearby cities and towns, and from the Eglin Air Force Base, which lies just to the south of the Yellow River into which many small tributaries flow.

Escambia River Basin

The Escambia River and its major tributary, the Conecuh River, drain the area of Florida just north of Pensacola. The river flows south and east into Escambia Bay at Pensacola. Industrial wastes from the Conecuh River, originate mostly in Alabama from paper manufacture and mining operations. The Alabama portion of the basin is largely agricultural. The Florida portion of the basin is dominated by the Pensacola metropolitan area. The economy is dependent on several large industries, operation of the port, the tourist industry, and on the military bases in the metropolitan area. The industrial wastes in the lower Escambia River and Escambia Bay are principally chemical and are highly nitrogenous materials. Sanitary sewage arising in the Conecuh River alters the bacteriological quality of the Escambia River below the Alabama-Florida state line. Many of the small communities in this basin have no treatment facilities or only primary treatment. The major interstate pollution problems in the Escambia River are high bacterial density and color. High color is attributed to industrial wastes from a container manufacturer. However, most all of this region is covered with trees and the area is somewhat swampy. Thus, some of the color originates from the decaying vegetation. Color levels do not interfere with any use of the water. There are sources of thermal and phosphorous wastes. Both of these would encourage high biological growths. A manufacturer of nylon fibre has been injecting strong organic and slightly acidic wastes into two deep rock strata injection wells, which apparently eventually discharge into the Gulf of Mexico. Most of the industries are providing at least partial waste treatment, either through in-plant changes or by improving the level of waste treatment. Regulated discharges from several plants, diffusion in deep water, and neutralization in holding ponds have been successful. The naval air station at Pensacola operates a primary sewage treatment plant, but also receives periodic discharges of industrial wastes, principally plating and engine cleaning wastes. One of the serious problems in the Pensacola area, while not directly on the Escambia River, is the Bayou Chico which receives a considerable load from many of the local industries and sewage discharges. Since the Bayou is almost totally enclosed, flow into the Gulf is highly restricted. The Conecuh River, while a major tributary to the Escambia River, was not covered in any of our original plans. Some mention is made of the pollutional contribution of the Conecuh River in the Escambia River summary. The major sources of pollution in the Conecuh River are from paper and mining. The many small towns situated on the Conecuh River contribute to localized pollution problems, largely domestic sewage, the aggregate of which influences the bacteriological quality of the Escambia River. Some of the small towns have no treatment, others have only primary treatment.

Perdido River

This river was not included in our original scope of the study. It is an interstate water since it forms most of the boundary between Florida and Alabama before its entry into the Gulf of Mexico. The river rises near the town of Bay Minette in Alabama, flows generally south 60 miles to Perdido Bay. The principal pollution problems arise largely from primary treated sewage from Bay Minette and also organic chemicals and paper mill wastes. Occasional phenolic wastes have been observed.

The waters of Perdido Bay and River are used for sport and commercial fishing, and recreation. Apparently none of the river itself is used for municipal water supply. Ground water is used primarily for this source.

Mobile River Basin

The Mobile River Basin drains one of the largest areas in the Southeast region, with water coming from Alabama, Georgia, Mississippi, and Tennessee. The average annual precipitation is almost 58 inches, one of the highest of any of the southeast basins. The Mobile River is formed by junction of the Alabama and the Tombigbee River, 40 miles north of Mobile. The large drainage area and unregulated flows on the two major tributaries cause highly variable flows, from dry conditions in the fall to spring floods. The upper three quarters of the Mobile River delta is a maze of rivers, bays, bayous and swamps with thick tree growth. The lower portion is treeless, with grass covered islands, marshes, and shallow bays. The delta is hemmed in on both sides by high land which is not typical of most deltas. The tidal effect in the bay is felt only once daily. Mobile Bay is in that portion of the Gulf coast where there is only one tide daily with a cycle of 25 hours. Water elevations in the bay are also affected by strong north winds which cause drops as much as 2 to 3 feet. The major pollution problems in the Mobile River Basin are from primary sewage discharge or industrial wastes of various types, such as from paper mills, meat packing plants, container manufacturers, and mineral industries. A considerable amount of untreated sewage is discharged directly into the Mobile River from the Mobile downtown area and from the Alabama State Docks. There is also industrial waste discharges from Blakeley Island which lies just across the Mobile River to the east of the main part of the city. Several small suburbs also have incomplete sewage treatment and are discharging wastes into several of the tributaries to the Mobile River. One of these streams is the Dog River which has been classified in the past as prime recreational water, but because of the pollution load, is now becoming unsafe for water contact sports. There was a major fish kill in the Dog River in 1968. The general quality of waters in the Mobile Basin is extremely variable. It ranges from grossly to moderately polluted waters in the Mobile metropolitan area to waters relatively pollution free in the outlying areas. This basin has been studied more than any other basin in Alabama.

The Mobile Bay area contributes a large volume of muddy water to the Gulf of Mexico. The bay is very wide and the average low mean water depth is 10 feet. The Corps of Engineers maintains a ship channel which is 40 by 400 feet down the bay from the dock and river area. There are shipping, building and other shipping activities. There are a number of industries in the upper bay region and its tributaries which have serious waste problems. Three Mile Creek and Chickasaw Creeks are particularly bad. The

Mobile River is navigable to commerical tow boats for its entire length.

The Alabama River is one of the largest rivers in the southeast region. It is formed by the junction of the Coosa and Tallapoosa Rivers north of Montgomery, then flows west and southwest to its junction with the Tombigbee River. The total length of the river is about 313 miles. The major sources of pollution on this river are domestic wastes from two large cities, two Air Force bases, industrial wastes from three paper mills, and occasional spills from an oil field. The water quality is generally good, except for bacteriological concentrations in the immediate vicinity of discharges of raw wastes. Several meat packing plants also discharge raw wastes into the river. Commercial and sport fishing, and in certain locations, recreation are the main uses of the river. The completion of several locks and dams on the river will also increase recreation. The river is not used as a source of public water supply. Several impoundments in the planning stage will also increase the use of the river for power generation and navigation.

Both the Coosa and Tallapoosa Rivers contain large amounts of mud. This is increased as the Alabama River flows toward the Mobile River. There are many sand bars in the stream. Each tributary stream creates a new one. The soil of the region is such to contribute to this type of erosion. The area is divided about half farms and half trees. The farming practices and soil characteristics both contribute. When the Alabama River joins the Tombigbee River to form the Mobile River, the mud load it carries engulfs the Tombigbee waters.

Tombigbee River

The Tombigbee River is formed by the junction of the east and west forks near Amory, Mississippi, it then flows south to southeast across Mississippi, and crosses the Alabama state line between Columbus, Mississippi and Gainesville, Alabama. It eventually is joined by the Black Warrior River at Demopolis, Alabama. The basin is primarily rural, sparsely populated, and has few sizeable towns. Flow in the Upper Tombigbee is not regulated; a dam at Demopolis impounds water from the mouth upstream to Gainesville, Alabama, approximately 60 miles. Very little water quality data are available on the Upper Tombigbee River, particularly for the sections of the river in Mississippi. A surveillance station of FWPCA is located near the Alabama-Mississippi state line downstream from Columbus, Mississippi. As in many other rivers in the southeast basin, the main stem of the Tombigbee River is generally of good quality. The tributaries, however, are responsible for much of the pollution load which has resulted in periodic fish kills extending into the Tombigbee River. A wide variety of industrial wastes, consisting of chemical, meat packing, sand and gravel, food, and paperboard wastes, as well as poorly and inadequately treated domestic wastes, are responsible for the waste problems in this watershed. Since the main stem of the Upper Tombigbee is generally considered to be prime commercial and sport fishing water, these periodic fish kills are quite serious.

The Upper Tombigbee River drains a forested area. The stream soon picks up a dark reddish brown color and high turbidity levels. Later this color becomes a creamy brown and later green, south of Columbus, Mississippi.

The Black Warrior River joins the Tombigbee River as a tributary stream at Demopolis, Alabama. There is commercial navigation on the Black Warrior and Tombigbee Rivers. There are proposals to extend the navigation area in the Upper Tombigbee River. This would include locks and dams with an added connection up to the Tennessee River. This may well be good for navigation. However, the effect of this on water quality should be carefully evaluated.

Downstream from Demopolis there is a paper plant which has inadequate treatment facilities since the discharge is still visible for over a mile downstream. This discharge also colored the river much darker than previously. Further downstream there is another paper plant which obtains a higher degree of treatment but the effluent still discolors the stream. The Tombigbee River drains a region which is heavily forested. Only about 10% of the land is not tree covered. This would also be responsible for some portion of the dark color of the river. It would appear that there are both natural and pollutional sources of the dark almost black color of this stream.

The Tombigbee River is used by both commerical river traffic and pleasure boats. The latter use is the lesser. The river has many bends so that the length of the tows are shorter than those on the Ohio River for instance.

The Lower Tombigbee River is that portion from its juncture with the Black Warrior River to the juncture with the Alabama River. The Lower Tombigbee River receives the bulk of the pollutional load from the Black Warrior River. There are three chemical firms, three paper mills, and two municipalities discharging wastes into the Lower Tombigbee

River. Organic chemicals, pesticides, oils, tars, and untreated domestic wastes are the major sources of pollution. Fish kills have been observed and commercial fishing in certain areas of the stream has been seriously curtailed or abandoned entirely. The Black Warrior River flows through the most populous and industrialized section of Alabama and brings a considerable amount of pollution from this area into the Tombigbee River at Demopolis. Both of these rivers are important for navigation, sources of industrial water supply, recreation, and both sport and commercial fishing.

There is a paper plant and steam plant south of Jackson, Mississippi. The paper plant wastes are visible for several miles downstream. Further south at several points there are chemical wastes discharged after treatment which still has visible effluents. These were quickly assimilated into the stream however. Some of these chemical plants are discharging effluents to tributaries which then enter the Tombigbee.

Pascagoula River

The Pascagoula River is in part an intrastate stream. It is formed by the juncture of Leaf and Chickasawhay Rivers. From this point at Merrill, Mississippi, into the estuary north of Pascagoula, the river flows in a meandering fashion and has numerous tributaries along its path. As the river proceeds southward, it flows through an area rich with bayous, oxbows, and swamps. The area is tree covered and the turbid water has a dark brown color. About ten miles north of Pascagoula, the river splits into an east and west branch. Both of these branches continue through rich bayou regions into the estuary where the Pascagoula River is joined by one of its major tributaries, the Escatawpa River at Moss Point. The Escatawpa joins the east branch of the Pascagoula River. The river then flows past the town of Gautier and Pascagoula into Pascagoula Bay, which joins the Mississippi Sound. The mouth has a delta area with many grass covered islands. From the estuary, which extends approximately 6 to 10 miles north and northwest of Pascagoula, tidal action is observed to at least River Mile 42 but not past River Mile 53. At this point, the classification of the Pascagoula River as an interstate stream ends. The major sources of pollution of the Pascagoula River appear to come from its main tributaries. In the estuary region, localized municipal and industrial wastes coupled with the severe load from the Escatawpa River are the main sources of pollution. The effects of the two northern tributaries are apparently not felt severely in the main stem of the Pascagoula River. The wastes in the tributaries are organic from municipal wastes and occasional high chlorides coming from oil field operations. Other tributaries such as the Black Creek have sources of pollution on their watersheds, but the effects on the main stem are minimal. The gross pollution in the bay area up into the estuary proper makes this water unsuitable for any commercial fishing, body contact sports and domestic supply. Shellfish harvesting has been seriously limited or halted in the estuary region because of gross pollution.

Pearl River

The Pearl River rises in east central Mississippi, flows southwest to Jackson, then south-southeast with the latter third of the stream being the boundary between the states of Mississippi and Louisiana. The river splits into a east and west branch. The east branch enters Lake Borgne, an arm of the Gulf of Mexico. The West Pearl enters the Rigolets passage between Lake Pontchartrain and Lake Borgne. The river is typically a southeast region river as the two branches flow through wooded bottoms and marsh lands. The two main stems are connected by a maze of bayous and small creeks. The waters of the basin are presently used for municipal and industrial supplies, recreation, commercial and sport fishing, navigation, and waste assimilation. The major problems of pollution are those arising from inadequately treated municipal wastes, pulp and paper mills, meat packing, chemicals, lumber, wood preserving, and occasional discharge of brines from oil fields. One plant discharges wastes containing zinc and phosphates. Occasional fish kills have been observed and the suspected source was land runoff containing pesticides. A pollution load imposed upon the stream makes certain stretches of the Pearl River marginal for fish propagation and undesirable for body contact sports. The characteristic problem with high coliform counts occasionally affects the shellfish industry in the lower reaches of the basin in Lake Borgne and in the Gulf Area.

The water discharged by the Pearl River in the Rigolet region is so high in organics that it foams due to wind and wave action. These organics most probably are due to natural sources. The delta region has filled up with mud flat islands which are grass covered. There is a NASA test facility which is connected by a short channel to the Pearl River. This could be a source of potential pollution to the Pearl River.

The lower section of the river, where the river forms the Louisiana-Mississippi state line, is for the most part heavily forested, whereas the section within Mississippi is more heavily farmed. The crops are cotton and sugar cane.

Interstate Water Quality Standards

Ochlockonee River

From Ochlockonee Bay to Lake Talquin Dam.

Florida

Interstate Water Quality Standards for the Ochlockonee River from the Bay to Lake Talquin Dam. See Class III Waters on pages 248 to 250 of this report.

Ochlockonee River

From Upper Lake Talquin to the Florida-Georgia State Line. See Class III Waters on pages 248 to 250 of this report.

Ochlockonee River

From Georgia-Florida State Line to its headwaters.

Georgia

Water Interstate Water Quality Standards for the Ochlockonee River from the Georgia-Florida State Line to its headwaters.

General Criteria for all Waters

All waters shall be free from materials associated with municipal or domestic sewage, industrial waste or any other waste which will settle to form sludge deposits and become putrescent, unsightly or otherwise objectionable.

All waters shall be free from oil, scum, and floating debris associated with municipal or domestic sewage, industrial waste or other discharges in amounts sufficient to be unsightly or to interfere with legitimate water uses.

All waters shall be free from material related to municipal, industrial, or other discharges which produce turbidity, color, odor, or other objectionable conditions which interfere with legitimate water uses.

All water shall be free from toxic, corrosive, acidic, and caustic substances discharged from municipalities, industries, or other sources in amounts, concentrations, or combinations which are harmful to human, animal, or aquatic life.

The maximum permissible concentration of radionuclides in the waters of the State must conform to the limits which are cited in Chapter 270-5-20 "Control of Radioactive Materials," of the Rules and Regulations of the Georgia Department of Public Health.

Criteria: Fishing, Propagation of Fish, Shellfish, Game, and Other Aquatic Life

Dissolved Oxygen - A minimum of 5.0 mg/l at all times for streams designated as trout waters by the State Game and Fish Commission: a minimum of 4.0 mg/l at all times for waters supporting warm water species of fish.

pH - Within the range of 6.0 - 8.5.

Bacteria - Fecal coliform not to exceed a mean of 5,000/100 ml (MPN) based on at least 4 samples taken over a 30 day period and not to exceed 20,000/100 ml in more than 5% of the samples in any 90 day period.

Temperature - Not to exceed 93.2°F (34.0°C.) at any time and not to be increased more than 10°F. above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

Toxic Wastes, Other Deleterious Materials - None in concentrations that would harm man, fish, and game or other beneficial aquatic life.

Apalachicola River

From Apalachicola Bay to Jim Woodruff Dam.

Florida

State Water Quality Standards. Classification Class III, Recreation, Propagation and Management of Fish and Wildlife, see pages 248 to 250 of this report.

Chattahoochee River

From Jim Woodruff Dam (Lake Seminole) to Georgia Highway 91 (Neal's Landing).

Georgia

Interstate Water Quality Standards.

Recreation

Bacteria - Fecal coliform not to exceed a mean of 1,000 per 100 ml (MPN) based on at least 4 samples taken over a 30 day period, and not to exceed 4,000 per 100 ml in more than 5% of the samples taken in any 90 day period.

Dissolved Oxygen - Not less than 4.0 mg/l except that those streams designated as trout waters by the State Game and Fish Commission must have a minimum of 5.0 mg/l at all times.

pH - Within the range of 6.0 - 8.5.

Toxic Wastes, Other Deleterious Materials - None in concentrations that would harm man, fish and game or other beneficial aquatic life.

Temperature - Not to exceed 93.2%F. (34.0°C.) at any time and not to be increased more than 10°F. above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

Chattahoochee River

From Neal's Landing to Great Southern Division of Great Northern Paper Company.

Georgia

Interstate Water Quality Standards.

Fishing, Propagation of Fish, Shellfish, Game and Other Aquatic Life, See pages 248 to 250 of this report.

Alabama

Interstate Water Quality Standards, classification Fish and Wildlife, see pages 251 to 252 of this report.

Chattahoochee River

From Great Southern Division of Great Northern Paper Company to Cowikee Creek.

Georgia

Interstate Water Quality Standards, classification Recreation, see page 241 of this report.

Drinking Water Supplies

Those waters approved by the Georgia Department of Public Health and requiring only approved disinfection and meeting the requirements of the latest edition of "Public Health Service Drinking Water Standards"; or waters approved by the Georgia Department of Public Health for human consumption and food-processing or for any other use requiring water of a lower quality.

Bacteria - Fecal coliform not to exceed a mean of 50 per 100 ml (MPN) based on at least 4 samples taken over a 30 day period and not to exceed 200 per 100 ml in more than 5% of the samples in any 90 day period.

Floating Solids - Settleable solids, sludge deposits or any taste, odor or color producing substances: None associated with any waste discharge.

Sewage, Industrial or Other Wastes - None

Those raw water supplies requiring approved treatment to meet the requirements of the Georgia Department of Public Health Service Drinking Water Standards" or which are approved by the Georgia Department of Public Health for human consumption and food-processing or for any other use requiring water of a lower quality.

Bacteria - Fecal coliform not to exceed a mean of 5,000 per 100 ml (MPN) based on at least four samples taken over a 30 day period and not to exceed 20,000 per 100 ml in more than 5% of the samples taken in any 90 day period.

Dissolved Oxygen - Not less than 4.0 mg/l at any time; a minimum of 5.0 mg/l at all times for waters designated as trout streams by the State Game and Fish Commission.

pH - With the range of 6.0 - 8.5.

No material or substance in such concentration that, after treatment, would exceed the requirements of the Georgia Department of Public Health and the latest edition of "Public Health Service Drinking Water Standards."

Temperature - Not to exceed 93.2°F. (34.0°C.) at any time and not to be increased more than 10°F. above intake temperature. In streams designated as trout waters by the State Game and Fish Commission, there shall be no elevation or depression of natural stream temperatures.

Alabama

Interstate Water Quality Standards, classification Public Water Supply, Swimming, Fish and Wildlife, see pages 251 to 253 and 256 to 257.

Chattahoochee River

From Osanippa Creek to West Point Manufacturing Company.

Georgia

Interstate Water Quality Standards, classification Fishing, see page 240 of this report.

Alabama

Interstate Water Quality Standards, classification Fish and Wildlife, see pages 251 to 252 of this report.

Chattahoochee River

From West Point Manufacturing Company to Alabama-Georgia State Line.

Georgia

Interstate Water Quality Standards, classification, Drinking Water, see page 240 of this report.

Alabama

Interstate Water Quality Standards, classification, Public Water Supply, Fish and Wildlife, see pages 251 to 253.

Chattahoochee River

From West Point Dam (Alabama-Georgia State Line) to Franklin, Georgia.

Georgia

Interstate Water Quality Standards, classification, Recreation, see pages 242 to 243 of this report.

Chattahoochee River

From Franklin, Georgia to Cedar Creek.

Georgia

Interstate Water Quality Standards, classification, Fishing, see pages 242 to 243 of this report.

Chattahoochee River

From Cedar Creek to Atlanta, Georgia.

Georgia

Interstate Water Quality Standards.

Industrial

For Processing and cooling water with or without special treatment; or for any other use requiring water of a lower quality.

Dissolved Oxygen - A daily average of 3.0 mg/l and not less than 2.5 mg/l at any time.

pH - Within the range of 6.0 - 8.5.

Toxic Substances; Other Deleterious Materials - None in amounts or concentrations that would prevent fish survival or interfere with legitimate and beneficial industrial uses.

Temperature - Not to exceed 93.2°F. (34.0°C.) at any time and not be increased more than 10°F. above intake temperature.

Chattahoochee River

From Atlanta, Georgia to Buford Dam.

Georgia

Interstate Water Quality Standards, classification, Drinking Water, see pages 242 to 243 of this report.

Chattahoochee River

From Buford Dam to Head waters.

Georgia

Interstate Water Quality Standards, classification, Recreation, see pages 242 to 243 of this report.

Flint River

From Jim Woodruff Dam (Lake Seminole) to Bainbridge U.S. Highway 84.

Georgia

Interstate Water Quality Standards, classification, Recreation, see pages 242 to 243 of this report.

Flint River

From Bainbridge to Albany, Georgia Power Company Dam at Lake Worth.

Georgia

Interstate Water Quality Standards, classification, Fishing, see pages 243 of this report.

Flint River

(Upper) from Lake Worth Power Dam to Georgia Highway 27.

Georgia

Interstate Water Quality Standards, classification, Recreation, see pages 242 to 243 of this report.

Flint River

From Georgia Highway 27 to Georgia Highway 16.

Georgia

Interstate Water Quality Standards, classification, Fishing, see pages 243 of this report.

Flint River

From Georgia Highway 16 to S1061, Woolsey Road.

Georgia

Interstate Water Quality Standards, classification, Drinking Water, see pages 242 to 243 of this report.

Flint River

From Woolsey Road to Georgia Highway No. 54.

Georgia

Interstate Water Quality Standards, classification, Fishing, see pages 242 to 243 of this report.

Flint River

From Georgia Highway No. 54 to Head Waters.

Georgia

Interstate Water Quality Standards, classification, Industrial, see page 245 of this report.

Choctawhatchee River

From Choctawhatchee Bay to Alabama-Florida State Line.

Florida

Interstate Water Quality Standards for the Choctawhatchee River from Choctawhatchee Bay to the Alabama-Florida State Line.

The Standards for this reach of the river, which is classified as a Class III (Recreation, Fish, and Wildlife) are given on pages 249 to 250 of this report.

Choctawhatchee River

From the Alabama-Florida State Line to its Source.

Alabama

Interstate Water Quality Standards for the Choctawhatchee River from the Alabama-Florida State Line to its source. See Fish and Wildlife Classification on pages 251 to 253 of this report.

Yellow River

From Blackwater Bay to Shoal River.

Florida

Interstate Water Quality Standards for the Yellow River from its Mouth to the Shoal River. See pages 249 to 250 of this report for Classification III (Recreation, Propagation, and Management of Fish and Wildlife.)

Yellow River

From the Shoal River to the Alabama-Florida State Line, also Class III, see pages 249 to 250 of this report.

Yellow River

From Alabama-Florida State Line to its Source.

Alabama

Interstate Water Quality Standards for the Yellow River from the Alabama-Florida State Line to its Source.

This reach of the Yellow River is classified in Alabama as Fish and Wildlife. These Standards may be found on pages 251 to 253 of this report.

Escambia River

From Escambia Bay to the Alabama State Line.

Florida

Interstate Water Quality Standards for that portion of the Escambia River from its Mouth to the Florida-Alabama State Line.

The Escambia throughout this reach is classified as a water applied to Recreation, Propagation and Management of Fish and Wildlife.

The following minimum conditions apply to all waters, at all times and places.

With the State all waters shall be free from:

Settleable Substances - Substances attributable to municipal, industrial, agricultural or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits.

Floating Substances - Floating debris, oil, scum, and other floating materials attributable to municipal, industrial, agricultural, or other discharges in amounts sufficient to be unsightly or deleterious.

Deleterious Substances - Materials attributable to municipal, industrial, agricultural or other discharges producing color, odor, or other conditions in such degree as to create a nuisance.

Toxic Substances - Substances attributable to municipal, industrial, agricultural, or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

Waste Waters Discharged to Coastal Waters will receive the best practicable treatment.

Criteria: Class III Waters - Recreation, Propagation and Management of Fish and Wildlife

pH - Of receiving waters shall not be caused to vary more than 1 (1.0) unit above or below normal pH of the waters: lower values shall not be less than 6.0 and upper values shall not be more than 8.5. In cases where pH may be due to natural background or causes outside limits stated above, approval of the regulatory agency shall be secured prior to introducing such material in waters of the State.

Dissolved Oxygen - Shall not be artificially depressed below the values of 4.0 ppm (unless background information available to the regulatory agency indicates prior existence under unpolluted conditions of lower values). In such cases, lower limits may be utilized after approval by the regulatory authority. (Waters of the open ocean shall be maintained at a DO of not less than 5 ppm. Streams specifically listed in section entitled, "Special Stream Classification," shall similarly be maintained at a minimum DO of 5 ppm.)

Bacteriological - Coliform group not to exceed 1,000/100 ml as a monthly average. (Either MPN or MF counts); nor to exceed this number in more than 20% of the samples examined during any month; nor exceed 2,400/100 ml (MPN or MF count) on any day. This criterion shall apply only to waters used for body contact activities.

Toxic Substances - See definition above under Minimum Conditions.

Deleterious Substances - See definition above under Minimum Conditions.

Turbidity - Shall not exceed 50 (50 J.T.U.) as related to standard candle turbidimeter above background.

Temperature - Shall not be increased so as to cause any damage or harm to the aquatic life or vegetation of the receiving waters or interfere with any beneficial use assigned to such waters.

A portion of Escambia Bay is classified as a Class II Water, suitable for Shellfish Harvesting. The bulk of the Bay is classed as Class III, as is the river.

Escambia Bay

From Pensacola Bay east of county line and south of L&N Railroad.

Criteria: Class II Waters - Shellfish Harvesting

Bacteriological Quality, Coliform Group - Areas classified for shellfish harvesting, the median coliform MPN of water cannot exceed 70/100 ml and not more than 10% of the samples ordinarily exceed an MPN of 230/100 ml in those portions of areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollutional conditions.

pH - See definition under Class III Waters, pages to of this report.

Temperature - See definition under Class III Waters, pages to of this report.

Dissolved Oxygen - See definition under Class III Waters, pages 249 to 250 of this report.

Toxic Substances - See definition under Class III Waters, pages 249 to 250 of this report.

Odor - Threshold odor number not to exceed 24 at 60°C as a daily average.

The Conecuh River is classified throughout its length from the Alabama-Florida State Line through Point A Dam and Lake to its source as a Fish and Wildlife stream. Point A Dam to the head of Gantt Lake is also classified as a water suitable for Swimming.

Conecuh River

From Alabama-Florida State Line to Point A Dam.

Alabama

Interstate Water Quality Standards for the portion of the Conecuh River from the Alabama-Florida State Line to Point A Dam.

pH - Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.0 nor greater than 8.5.

Temperature - The ambient temperature of receiving waters, in degrees F., after reasonable mixing, shall not be increased by more than 10% by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees F., except that the temperature may be as high as 93 degrees F. for not more than eight hours during any 24 hour period.

Dissolved Oxygen - Sewage, industrial wastes or other wastes shall not cause the dissolved oxygen to be less than 4.0 ppm as measured at a depth of 5 feet in water 10 feet or greater in depth and at mid-depth in waters less than 10 feet deep.

Toxic Substances Attributable to Sewage, Industrial Wastes, or Other Wastes - Only such amounts, whether alone or in combination with other substances, as will not: be injurious to fish and aquatic life including shrimp and crabs in estuarine or salt waters or the propagation thereof; not to exceed one-tenth of the 48-hour median tolerance limit for fish and aquatic life including shrimp and crabs in salt and estuarine waters except that other limiting concentrations may be used when factually justified and approved by the Commission.

Taste, Odor and Color Producing Substances Attributable to Sewage, Industrial Waste and Other Wastes - Only such amounts, whether alone or in combination with other substances as will not be injurious to fish and aquatic life including shrimp and crabs in estuarine and salt waters or adversely affect the propagation thereof: impair the palatability or marketability of fish and wildlife or shrimp and crabs in estuarine and salt waters; unreasonably affect the aesthetic value of waters for any use under this classification.

Conecuh River

From Point A Lake to Head of Gantt Lake.

Alabama Water Quality Standard Criteria (Swimming and Other Whole Body Water-Contact Sports)

pH - See Fish and Wildlife classification above, pages 249 to 250 of this report.

Temperature - See Fish and Wildlife classification above, pages 249 to 250 of this report.

Dissolved Oxygen - See Fish and Wildlife classification above, pages 249 to 250 of this report.

Toxic Substances; Color Producing Substances; Odor Producing Substances; or Other Deleterious Substances Attributable to Sewage, Industrial Wastes or Other Wastes - Only such amounts, whether alone or in combination with other substances or wastes, as will not: render the water unsafe or unsuitable for swimming and water-contact sports: be injurious to fish, wildlife and aquatic life or, where applicable, shrimp and crabs; impair the palatability of fish, or, where applicable, shrimp and crabs; impair the waters for any other usage established for this classification or unreasonably affect the aesthetic value of waters for any use under this classification.

Bacteria - Waters in the immediate vicinity of discharges of sewage or other wastes likely to contain bacteria harmful to humans, regardless of the degree of treatment afforded these wastes are not considered acceptable for swimming or other whole body water-contact sports. In the event there are discharges of sewage or other wastes likely to contain bacteria harmful to humans to waters within the watershed above the point of use for swimming and other whole body water-contact sports, the following bacteriological criteria are to apply: bacteria of the fecal coliform group not to exceed 1,000 per 100 milliliters (MPN or MF count) as a monthly average value during the months of May through September, nor exceed this value in any two consecutive samples collected during these months. In the event a sanitary survey reveals no discharges of sewage or other wastes likely to contain bacteria harmful to humans within the watershed above the point of use for swimming and other whole body water-contact sports, these bacteriological criteria, at the discretion of the Commission, may not apply.

This reach of the Conecuh River is also classified suitable for Fish and Wildlife. The criteria in the lower reach of the river would apply as well. See pages to of this report.

Conecuh River

From the Head of Gantt Lake to its source.

This reach of the Conecuh River is also classified as Fish and Wildlife. See page 252 of this report.

Perdido River

From Perdido Bay to its Source.

Alabama

Interstate Water Quality Standards classification, Fish and Wildlife, see pages 249 to 250 of this report.

Perdido River

From Perdido Bay to Florida-Alabama State Line.

Florida

Interstate Water Quality Standards, Classification III, Recreation, Propagation and Management of Fish and Wildlife, see pages 249 to 250 of this report.

Mobile River and Mobile Bay

(Mobile Bay is divided into three portions, all of which are suitable for Fish and Wildlife. The Fish and Wildlife classifications for Alabama have been given, see pages 251 to 252 of this report.

Mobile Bay

That portion lying south of a line extending in an easterly direction from the south bank of East Fowl River at its Mouth through a lighted beacon (SL 2 sec.) to lighted beacon (FLG 4 sec. "23") at the Mobile Ship Canal, then in a northeasterly direction to Daphne. Alabama Interstate Water Quality Standards Shellfish Harvesting and Fish and Wildlife. For Fish and Wildlife classifications see pages 251 to 252 of this report.

Shellfish Harvesting

pH - Sewage, industrial wastes or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.5 nor greater than 8.5.

Temperature - The ambient temperature of receiving waters, in degrees F., after reasonable mixing, shall not be increased by more than 10 percent by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90 degrees F., except that the temperature may be as high as 93 degrees Fahrenheit for not more than 8 hours during any 24 hour period.

Dissolved Oxygen - Sewage, industrial wastes or other wastes shall not cause the dissolved oxygen to be less than 4.0 ppm as measured at a depth of 5 feet in waters 10 feet or greater in depth and at mid-depth in waters less than 10 feet in depth.

Toxic Substances Attributable to Sewage, Industrial Waste or Other Wastes - Only such amounts, whether alone or in combination with other substances, as will not: be injurious to fish and aquatic life, including shrimp and crabs; affect the marketability of fish and shellfish, including shrimp and crabs; exceed one-tenth of the 48 hour median tolerance limit for fish, aquatic life or shellfish including shrimp and crabs.

Color, Taste and Odor Producing Substances and Other Deleterious Substances Attributable to Sewage, Industrial Wastes or Other Wastes - Only such amounts, whether alone or in combination with other substances, as will not: be injurious to fish and shellfish, including shrimp and crabs; adversely affect marketability or palatability of fish and shellfish, including shrimp and crabs; unreasonably affect the aesthetic value of waters for any use under this classification.

Bacteria - Not to exceed the limits specified in the latest edition of the National Shellfish Sanitation Program Manual of Operations, Sanitation of Shellfish Growing Areas, published by the Public Health Service, U. S. Department of Health, Education and Welfare.

Mobile Bay

South of the line drawn due east from the Mouth of Dog River and east of the line drawn due south from the western shore of Chacaloochee Bay and all other portions of Mobile Bay.

Fish and Wildlife - See pages 251 to 252 of this report.

Swimming - See pages 252 to 253 of this report.

Mobile Bay

West of a line drawn due south from the western shore of Chacaloochee Bay to a point due east of the mouth of Dog River.

Fish and Wildlife - See pages 251 to 253 of this report.

Mobile River

From its Mouth to Spanish River.

Agricultural and Industrial Water Supply

pH - Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.0 nor greater than 8.5.

Temperature - The ambient temperature of receiving waters, in degrees F., after reasonable mixing, shall not be increased by more than 10% by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90°F., except that the temperature may be as high as 93°F. for not more than 8 hours during any 24 hour period.

Dissolved Oxygen - Sewage, industrial waste or other wastes shall not cause the dissolved oxygen to be less than 2.0 ppm as measured at a depth of 5 feet in waters 10 feet or greater in depth and at mid-depth in waters less than 10 feet in depth.

Color, Odor and Taste Producing Substances, Toxic Substances, and Other Deleterious Substances, Including Chemical Compounds, Attributable to Sewage, Industrial Wastes and Other Wastes - Only such amounts as will not render the waters unsuitable for agricultural irrigation, livestock watering, industrial cooling, industrial process water supply purposes and fish survival.

Mobile River

From Barry Steam Plant to Tensaw River.

Fish and Wildlife - See pages 251 to 252 of this report.

Public Water Supply

pH - Sewage, industrial waste or other wastes shall not cause the pH to deviate more than one unit from the normal or natural pH nor be less than 6.0 nor greater than 8.5

Temperature - The ambient temperature of receiving waters, in degress F., after reasonable mixing, shall not be increased by more than 10% by the addition of domestic, industrial or other wastes nor shall these wastes cause the temperature of the receiving waters to exceed 90°F, except that the temperature may be as high as 93°F. for not more than 8 hours during any 24 hour period.

Dissolved Oxygen - Sewage, industrial waste or other wastes shall not cause the dissolved oxygen to be less than 4.0 ppm as measured at a depth of 5 feet in waters 10 feet or greater in depth and at mid-depth in waters less than 10 feet in depth.

Toxic Substances; Color Producing Substances; Heated Liquids; or Other Deleterious Substances Attributable to

Sewage, Industrial Wastes or Other Wastes - Only such amounts, whether alone or in combination with other substances, and only such temperatures as will not render the waters unsafe or unsuitable as a source of water supply for drinking or food-processing purposes, or injurious to fish, wildlife and aquatic life, or adversely affect the aesthetic value of waters for any use under this classification.

Taste and Odor Producing Substances Attributable to Sewage, Industrial Wastes, or Other Wastes - Only such amounts, whether alone or in combination with other substances or wastes, as will not, cause taste and odor difficulties in water supplies which cannot be corrected by treatment as specified under "Conditions Related to Best Usage," or impair the palatability of fish.

Bacteria - In the event there are discharges of sewage, or other wastes likely to contain bacteria harmful to humans, to waters within the watershed above the point of taking water for purposes of public water supply or waters for food-processing purposes, after conventional treatment, the following bacteriological criteria are to apply: bacteria of the fecal coliform group not to exceed 5,000 per 100 ml (either MPN or MF count) as a monthly average value; nor exceed this number in more than 20% of the samples examined during any month; nor exceed 20,000 per 100 ml in more than 5% of the samples examined during one month.

Alabama River

From Mobile River to Claiborne Lock and Dam.

Alabama

Interstate Water Quality Standards for the above reach.

Fish and Wildlife - see pages 251 to 252 of this report.

Alabama River

From Claiborne Lock and Dam to Frisco Railroad Crossing.

Alabama

Interstate Water Quality Standards.

Swimming - See pages 252 to 253 of this report.

Fish and Wildlife - See pages 251 to 252 of this report.

Alabama River

From Frisco Railroad Crossing to Miller's Ferry Lock and Dam.

Alabama

Interstate Water Quality Standards.

Fish and Wildlife - See pages 251 to 252 of this report.

Alabama River

From Miller's Ferry Lock and Dam to Blackwell Bend (Six Mile Creek).

Swimming - See pages 252 to 253 of this report.

Fish and Wildlife - See pages 251 to 252 of this report.

Alabama River

From Blackwell Bend to Jones Bluff Lock and Dam.

Fish and Wildlife - See pages 251 to 252 of this report.

Alabama River

From Jones Bluff Lock and Dam to Pintlalla Creek.

Swimming - See pages 252 to 253 of this report.

Fish and Wildlife - See pages 251 to 252 of this report.

Alabama River

From Pintlalla Creek to its Source.

Fish and Wildlife - See pages 251 to 252 of this report.

Tombigbee River

From the Mobile River to One Mile Downstream from U.S. Highway 43.

Alabama

Interstate Water Quality Standards.

Fish and Wildlife - See pages 251 to 252 of this report.

Tombigbee River

One Mile Downstream from U.S. Highway 43 to Five Miles Upstream from U.S. Highway 43.

Public Water Supply, Swimming, Fish and Wildlife - See pages 256 to 257 and 251 to 253 of this report.

Tombigbee River

Five Miles Upstream from U.S. Highway 43 to Jackson Lock and Dam.

Fish and Wildlife - See pages 251 to 252 of this report.

Tombigbee River

From Jackson Lock and Dam to Beach Bluff.

Swimming, Fish and Wildlife - See pages 251 to 253 of this report.

Tombigbee River

From Beach Bluff to Demopolis Lock and Dam.

Fish and Wildlife - See pages 251 to 252 of this report.

Tombigbee River

From Demopolis Lock and Dam to Warrior River.

Swimming, Fish and Wildlife - See pages 251 to 253 of this report.

Upper Tombigbee River

From Junction with Warrior River to Cobb Creek.

Alabama

Interstate Water Quality Standards for the Upper Tombigbee River from Warrior River to Cobb Creek. Classification Swimming, Fish and Wildlife - See pages 251 to 253 of this report.

Upper Tombigbee River

From Cobb Creek to Alabama-Mississippi State Line.

Fish and Wildlife - See pages 251 to 253 of this report.

Upper Tombigbee River

From Mississippi-Alabama State Line to its Headwaters (East Fork).

Mississippi

Interstate Water Quality Standards, classification Fish and Wildlife - See pages 262 to 263 of this report. See also minimum condition applicable to all waters, page 261 of this report.

Pascagoula River

Basin and Pascagoula Bay.

Minimum Conditions Applicable to All Waters

Free from substances attributable to municipal, industrial, agricultural or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits.

Free from floating debris, oil, scum and other floating materials attributable to municipal, industrial, agricultural or other discharges in amounts sufficient to be unsightly or deleterious.

Free from materials attributable to municipal, industrial, agricultural or other discharges producting color, odor, or other conditions in such degree as to create a nuisance.

Free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to humans, animal, or aquatic life.

Municipal wastes, industrial wastes, or other wastes shall receive effective treatment or control (secondary or equivalent) in accordance with the latest practical technological advances and shall be approved by the Commission. A degree of treatment greater than secondary will be required when necessary to protect legitimate water uses.

Mississippi

Interstate Water Quality Standards for Pascagoula Bay.

Criteria: Agricultural and Industrial Water Supplies

Waters in this classification will be suitable for agricultural irrigation and livestock watering, industrial cooling and process water supplies, fish survival and other uses, except fish and wildlife propagation, water contact sports and source of potable water supply.

Dissolved Oxygen - There shall be no oxygen demanding substances added which will depress the dissolved oxygen content below 3.0 mg/l.

pH - The pH shall not be caused to vary more than 1.0 unit above or below normal pH of the waters and lower value shall be not less than 6.0 and upper value not more than 8.5.

Temperature - Shall not be increased more than ten degrees F (10°F) above the natural prevailing background temperatures, nor exceed a maximum of 93°F after reasonable mixing.

Specific Conductance - There shall be no substances added to increase the conductivity above 1,000 micromhos/cm for fresh water streams.

Dissolved Solids - There shall be no substances added to the waters to cause the dissolved solids to exceed 750 mg/l as a monthly average value, nor exceed 1,500 mg/l at any time.

Pascagoula River

From Pascagoula Bay to Confluence of Escatawpa River. See Agricultural and Industrial Classification, pages 261 to 262.

Pascagoula River

From Confluence of Escatawpa River to River Mile 53.

Mississippi

Interstate Water Quality Standards for the Pascagoula River from the Confluence of the Escatawpa River to River Mile 53.

Fish and Wildlife

Waters in this classification are intended for fishing, propagation of fish, aquatic life and wildlife and any other uses requiring water of lesser quality.

Dissolved Oxygen - There shall be no oxygen demanding substances added which will depress the D.O. content below 4.0 mg/l.

pH - See Agricultural and Industrial Uses, pages 261 to 262 of this report.

Temperature - See Agricultural and Industrial Uses, pages 261 to 262 of this report.

Specific Conductance - See Agricultural and Industrial Uses, pages 261 to 262 of this report.

Dissolved Solids - See Agricultural and Industrial Uses, pages 261 to 262 of this report.

Toxic Substances - There shall be no substances added to the waters to exceed one-tenth (1/10th) of the 48 hour median tolerance limit.

Taste and Odor - There shall be no substance added, whether alone or in combination with other substances, that will impair the palatability of fish or unreasonably affect the aesthetic value of the water.

Phenolic Compounds - There shall be no substances added which will cause the phenolic content to exceed 0.05 mg/l (phenol).

Pearl River

From its mouth at Lake Borgne to a point ten miles downstream from Jackson, Mississippi.

Mississippi

Interstate Water Quality Standards, classification Recreation.

Recreation

Waters in this classification are to be used for recreational purposes, including such water contact activities as swimming and water skiing. The waters shall also be suitable for use for which waters of lower quality will be satisfactory.

In assigning this classification to waters intended for water contact sports, the Commission will take into consideration the relative proximity of discharge of wastes and will recognize the potential hazards involved in locating swimming areas close to waste discharges. The Commission will not assign this classification to waters, the bacterial quality of which is dependent upon adequate disinfection of waste and where the interruption of such treatment would render the waters unsafe for water contact sports.

Dissolved Oxygen - There shall be no oxygen demanding substances added which will depress the D.O. content below 4.0 mg/l.

pH - The pH shall not be caused to vary more than 1.0 unit above or below normal pH of the waters and lower value shall be not less than 6.0 and upper value not more than 8.5.

Temperature - Shall not be increased more than ten degrees F (10°F) above the natural prevailing background temperatures, nor exceed a maximum of 93°F after reasonable mixing.

Bacteria - Fecal coliform not to exceed 1000 per 100 ml as a monthly average value (either MPN or MF count); nor exceed this number in more than twenty percent (20%) of the samples examined during any month; nor exceed 2,400 per 100 ml (MPN or MF count) on any day.

Specific Conductance - There shall be no substances added to increase the conductivity above 1000 micromhos/cm for fresh water streams.

Dissolved Solids - There shall be no substances added to the waters to cause the dissolved solids to exceed 750 mg/l as a monthly average value, nor exceed 1500 mg/l at any time.

Toxic Substances, Color, Taste and Odor Producing Substances - There shall be no substances added, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities, or impair the use of waters requiring lesser quality.

Louisiana

Interstate Water Quality Standards.

This portion of the Pearl River, which forms the border of Louisiana and Mississippi is divided into two zones and by Louisiana Stream Control Commission.

Zone One - That portion of the Pearl River above the uppermost point of influx of marine water with tidal action.

General Criteria - Wastes after discharge to the Pearl River shall not create conditions which will adversely affect public health or use of the water for the following purposes: domestic or industrial water supply, propagation of aquatic life, agricultural water, recreation, and other legitimate uses.

Specific Criteria

pH - With the range of 6.0 - 8.5.

Dissolved Oxygen - Not less than 50% of saturation at existing water temperature.

Temperature - Not to be raised more than 3°C above normal ambient water temperature nor exceed a maximum of 36°C.

Oils - There shall be no slicks of free or floating oil present in sufficient quantities to interfere with the designated uses, nor shall emulsified oils be present in sufficient quantities to interfere with the designated uses.

Toxic Materials - None present in quantities that alone or in combination will be toxic to animal or plant life. In all cases, the level shall not exceed $TLM_{48}/10$.

Taste and Odor - Below levels of detection following normal water treatment and below levels that will produce objectionable odor in food fish and seafood.

Coliforms (MPN/100 ml) - The monthly median shall not exceed 1,600/100 ml nor shall this count exceed 5,420/100 ml in more than 10% of the samples in any one month.

Foaming or Frothing Materials - None of a persistent nature.

Floating, Suspended, and Settleable Solids - None that will produce floating masses, sludge banks, or beds on the bottom either organic or inorganic of other than natural origin.

Other Materials - Limits on other substances not heretofore specified shall be in accordance with recommendations set by the Louisiana Stream Control Commission and/or the Louisiana State Board of Health for municipal raw water sources.

Zone Two - The estuarine area from Lake Borgne to the uppermost point of influx of marine waters with tidal action.

General Criteria - The waters in Zone Two are not suitable for municipal water supply and most industrial applications because of their high salt content, a result of tidal influx of marine waters. Therefore, it is anticipated that water use in this zone will be limited to recreation and propagation of aquatic fauna including shellfish; all discharges will be such as to assure water of a quality that is adequate for these purposes.

Specific Criteria

pH - Within the range of 6.0 - 9.5.

Dissolved Solids - Not less than 50% of saturation at existing water temperature.

Temperature - Not to be raised more than 3°C above normal ambient water temperature, nor to exceed a maximum of 36°C.

Oils - There shall be no slicks of free or floating oil present in sufficient quantities to interfere with the designated uses nor shall emulsified oils be present in sufficient quantities to interfere with the designated uses.

Pearl River

From point ten miles downstream to City of Jackson.

Mississippi

Interstate Water Quality Standards, classification Fish and Wildlife, see pages 262 to 263 of this report.

Pearl River

From City of Jackson to Barnett Reservoir.

Mississippi

Interstate Water Quality Standards, classification Public Water Supply.

Public Water Supply

Water in this classification is for use as a source of raw water supply for drinking and food processing purposes. The water treatment process shall be approved by the Mississippi State Board of Health. The raw water supply will be such that after approved treatment process it will meet the Public Health Service Drinking Water Standards (latest edition).

Dissolved Oxygen - There shall be no oxygen demanding substances added which will depress the D.O. content below 4.0 mg/l.

pH - The pH shall not be caused to vary more than 1.0 unit above or below normal pH of the waters and lower value shall be not less than 6.0 and upper value not more than 8.5.

Temperature - Shall not be increased more than ten degrees F (10°F) above the natural prevailing background temperatures, nor exceed a maximum of 93°F after reasonable mixing.

Bacteria - Fecal coliform not to exceed 5,000 per 100 ml as a monthly average value (either MPN or MF count); nor to exceed this number in more than twenty percent (20%) of the samples examined during any month; nor to exceed 20,000 per 100 ml in more than five percent (5%) of such samples.

Chlorides (Cl^-) - There shall be no substances added which will cause the chloride content to exceed 250 mg/l in fresh water streams.

Specific Conductance - There shall be no substances added to increase the conductivity above 500 micromhos/cm for fresh water streams.

Dissolved Solids - There shall be no substances added to the waters to cause the dissolved solids to exceed 500 mg/l.

Threshold Odor - There shall be no substances added which will cause the threshold odor number to exceed 24 (at 60°C) as a daily average.

Phenolic Compounds - There shall be no substances added which will cause the phenolic content to be greater than 0.001 mg/l (phenol).

Radioactive Substances - There shall be no radioactive substances added to the waters which will cause the gross beta activity (in the known absence of Strontium-90 and alpha emitters) to exceed 1000 micromicrocuries at any time.

Chemical Constituents - Not to exceed the following concentrations at any time:

Constituent	Concentration (mg/l)
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.2
Fluoride	0.7 - 1.2
Lead	0.05
Selenium	0.01
Silver	0.05

Pearl River

From Barnett Reservoir to Head Waters.

Mississippi

Interstate Water Quality Standards, classification Fish and Wildlife, see pages 262 to 263 of this report.

APPENDIX III - MISSOURI RIVER BASIN

River Basin Descriptions

Lower Missouri River

The rivers and tributaries to be included in those of the Lower Missouri River Basin are as follows:

The Lower Missouri River drains Southeastern Wyoming, Northeastern Colorado, all of Nebraska, Kansas, Missouri, and Western Iowa. The Missouri River undercuts its banks and carries a great amount of silt. It normally floods during the spring, dwindles the rest of the year, and deposits its load as shifting sandbars. The Missouri River is a valuable source of hydroelectric power and water for irrigation.

The area of interest in the present project begins at its mouth at the Mississippi River and goes upstream to the Niobrara River, which joins the Missouri River at Niobrara, Nebraska. This is approximately 35 miles upstream from the Gavin's Point Dam on which forms the Lewis & Clark on the main stem of the Missouri River.

The section of the river between Kansas City and St. Louis has manufacturing and related services as the major economic activity. The major pollutants are untreated municipal and industrial wastes.

Over half of the basin population is concentrated in cities. Agriculture and manufacturing are the major economic activities in the basin; 45% of the manufacturing activity is attributed to food processing. The major pollutant sources are: irrigation return flows which is characterized by nitrates, phosphates, insecticides, suspended sediment, and organic pollution; feedlot runoff which is characterized by organic, bacterial pollution, and floating solids; and municipal wastes which is characterized by bacterial pollution.

Incoming flows of the Missouri River upstream from Kansas do not meet quality standards due primarily to large quantities of untreated meat packing wastes from the city of Omaha, Nebraska, and uncontrolled land drainage. There are construction schedules which should diminish this problem.

The quality of the water in the Lower Missouri River Basin does not meet objectives of the basin standards from the standpoint of dissolved oxygen, coliform bacteria, grease, and debris.

The cities of Kansas City, Kansas, and Kansas City, Missouri have recently constructed waste treatment plants. Thus, essentially all municipal and industrial wastes of the Missouri River common to both Kansas and Missouri will have the equivalent of primary treatment. It will be necessary to monitor treated waste discharges from Kansas City for wastes not amenable to primary treatment.

The Missouri River as it enters the Mississippi River is very muddy, and discolors the entire river within a short distance. The Missouri River is broad with wide curves. The banks of these curves tend to be undercut. The Corps of Engineers has built many dikes to protect these banks. Some are just wood piles whereas others are rock covered to protect them. These dikes are built out at an angle from the bank, especially at the curves. For flood control, there are many miles of levees along the banks.

There are many cut-offs which are called sloughs in this part of the country. These may support high algae populations. The Missouri River has some commercial navigation but very little pleasure boating when compared to other rivers in this country. Only two pleasure boats were observed in use on the lower 500 miles.

There are limestone quarries and mines along the banks in the section near the Gasconade River. These could contribute some alkalinity to the stream.

There are a number of power stations of which some evidence thermal discharge problems. Some industrial wastes come in from the Big Blue River. There are steel mills and refineries in this area which have a definite industrial waste.

There is a nuclear power station being constructed at river mile 532.5 which could be monitored at least for radiological at the proposed Rulc sampling station.

Above river mile 753, the river is considered to be not navigable at least to commercial craft. This upper portion has many islands which are almost mud flats with mud ponds and channels in them.

Lewis & Clark Lake has some recreational boating and fishing. The upper end of this lake at the mouth of the Niobrara River was the upper limit of the river observed.

Osage River

The Osage River is navigable over the lower 200 miles during high flow. This river contains large organic loads, high coliform densities, and floating solids with oxygen depletion and low pH in places.

The channel of the Osage River is deeper than the other tributaries of the Missouri Rivers. It does not have the sandbars or islands that are usually present, and its banks are straighter and cleaner. The Osage River is more turbid than most of its tributaries.

The Bagnel Dam is a hydroelectric structure that also forms a large recreation area called Lake of the Ozarks. This area has many recreational homes and small boats. Some pollution is in evidence near the marinas.

The Morais des Cygnes River joins with the Little Osage River to form the Osage River. The area drained by the Morais des Cygnes River is all agricultural with a few small towns. There are acid mine drainages periodically, however, the high turbidity of the river masks these discharges.

The Little Osage River drains an area which is more heavily wooded than the rest of the Lower Missouri River Basin. Approximately 40-50% of the land is covered by trees with the balance in farms. This small, narrow stream meanders over these flat lands with banks that are tree-lined.

Kansas River Basin

The Kansas River receives effluents from the municipal drainages of several cities and is also a source of potable water. The farm crops are varied and there are many irrigation diversions. The lower reach of the river receives industrial wastes. In this basin, agriculture, food processing and agricultural industry services are the primary economic activities. The largest population center contains only 16% of the total basin population and major pollutants are contributed by irrigation return flows, feedlot runoff, food processing, and municipalities. Pollution problems are indicated by oxygen depletion, turbid waters, and floating solids. The one unusual pollution source is located near DeSota, Kansas, and contributes undesirably high concentrations of lead, nitrates, and sulfates.

All river basins in Kansas are subject to pollution from agricultural sources. The primary pollutants in order of importance are livestock wastes, silt, nutrients, and pesticides, all of which are associated with uncontrolled land surface drainage during periods of rainfall.

There are many oxidation lagoons with varieties of successful treatment. There are a number of cattle feedlot operations with and without treatment. Topeka, although it is mainly a grain center, has municipal and industrial wastes. There are industrial wastes in the Delaware River and some petrochemical and municipal wastes near Lawrence, Kansas. In the Kansas City area, there are more municipal and industrial wastes.

The *Republican* River is one of the streams which joins to form the Kansas River; it contributes low concentrations of dissolved solids. The river drains a vast agricultural area. Bank erosion is controlled by the use of abandoned automobile bodies. The river is navigable to small boats.

In the Nebraska area of the Republican River, there are some irrigation diversions. There are small cattle feedlots and many oxidation lagoons. The sections of the river in Nebraska and downstream in Colorado have the characteristics noted in the Platte, North Platte, and South Platte Rivers. It is a shallow meandering stream with lush growth near the stream and sparse growth away from it. The section within Colorado is considered to be a temporary stream. The state of Colorado has not issued Water Quality Standards for it specifically; it would, however, be treated under their general statutes.

The *Smoky Hill* River joins with the Republican River to form the Kansas River. It drains an agricultural area. The water quality of the Smokey Hill River exceeds the water quality standards due to natural chlorides, sulfates, and total dissolved solids. There are irrigation returns which add to the increased mineralization of the stream. The portion in Colorado is considered a temporary stream and drains a praire. There are places where occasionally the stream is completely dry with improved roads built over it.

There are a number of reservoirs which have combined flood control and irrigation storage capacities. There is an oil field near Russell, Kansas which could contribute some waste problems. The Saline River contributes to the mineralization of the Smoky Hill River.

Platte River Basin

This river basin is similar to the Niobrara River Basin, in that the major economic activity is agriculture and the largest population center contains only 13% of the basin population. The dissolved solids contributed in the South Platte subbasin will be diluted somewhat by the North Platte River. The Platte River does not appear to be navigable except to small craft in a few areas. These areas are located on some of the reservoirs and near its mouth.

Pollution problems are indicated by oil, grease, bacteria, pesticides, soil minerals, and fertilizers which result in tastes and odors in water supplies withdrawn from the stream.

There is a major rail yard in North Platte, Nebraska, and also a stock yard which seems to have adequate treatment facilities installed. There are many irrigation diversions with considerable sediment and dissolved minerals in the return flows. The terrain results in spring floods up to a mile wide. The river channel is filled with sandbars and islands; these and the banks are tree-lined. The river basin is green as are the irrigated areas, but the rest of the land is praire and sand hills.

There are many sugar beet processes and cattle feedlot areas. The adequacy of treatment is varied. The eastern portion of the river basin is farmed to a greater extent than is the western section.

There are many new lakes adjacent to the Platte River which were formed when sand and gravel was dredged for use as raw materials in the construction of an Interstate Highway which parallels the stream. These have a beneficial effect on the quality of the stream and provide good recreation areas.

South Platte River Basin

In this basin, 70% of the population is concentrated in Denver, Colorado. The major economic activity is food processing and related services. A portion of the Denver municipal water supply is taken from the South Platte River. The headwaters originate high in the mountains above Denver. There are some mineral contributions from old drift and strip mines in the area which contribute some minerals to the water.

The major pollutants have a high oxygen demand, indicated by high coliform densities, with floating and suspended solids. Pollution problems are indicated by measurable grease, oil, phenol, and chromium in the stream.

There are 26 municipal sewage treatment plants in the Metropolitan Denver area. Four of these plants are for Federal Institutions. A large percentage of these treatment plants are approaching design capacity or have already exceeded it.

The chief source of recharge to the aquifer is from seepage of South Platte River water diverted to the irrigation ditches. Approximately 50% of this diverted river water enters the aquifer. Much of the valley-fill aquifer in Sand Creek Valley is contaminated by petroleum waters.

ABS is found through most of the valley-fill aquifer. The principle source is sewage-laden recharge water from the South Platte River, Sand Creek, and Clear Creek. High nitrate concentrations occur in and near irrigated lowland areas.

Approximately 12 square miles in the vicinity of the Rocky Mountain Arsenal has been contaminated by wastes discharged into unlined holding ponds and First Creek. Contaminants in the aquifer are chloride, fluoride, arsenic, chlorate, the herbicide 2, 4-D, and the pesticides aldrin and dieldrin. Saline water from the shallow contaminated zone in this vicinity has likely entered the underlying bedrock aquifers through defective deep wells. Of the industrial plants within the South Platte River Basin, over two-thirds are in the Denver Metropolitan Area.

The meat industry includes many separate plants and the Denver Union Stockyard Company. The paunch discharges are over 125 tons/day. Some of the paunch are discharged to the sanitary sewers, and some to the local fertilizer companies and farmers. There are problems created by the paunch going to municipal treatment plants. New treatment plants are being built to help out.

Manure in the livestock holding pens in the Denver area, exclusive of feedlot operations, accumulates at 200 tons/ day. This waste material is collected and delivered to local fertilizer companies or to farmers. Spent livestock drinking water is discharged to the South Platte River.

Three companies with rendering facilities dispose of part or all of their wastes from this operation to the South Platte River. Most all of meat plants provide some form of grease removal and recovery. Some of these facilities are marginal with excess grease released to the sanitary sewers or to the South Platte River.

There are two railroad maintenance yards in the Metropolitan Denver area that, although they use oil separators before discharging to the river, contribute substantial quantities of oil to the river.

Beet sugar wastes are the largest source of pollution within the study area. Sugar factories are dispersed throughout the region and affect the water quality in over 300 miles of basin streams.

There are many cattle feedlots along the South Platte River. These can contribute high BOD loading as well as high bacteria counts.

There are a number of reservoirs adjacent to the river which have water diverted to them, especially in high flow periods. These then supply low flow augmentation to the irrigation canals.

Total withdrawals of ground water are estimated at about 1.22 million acre-feet/year. Agricultural irrigation is the largest user of ground water; withdrawals were approximately 1.17 million acre-feet in 1966 and comprised 96% of the total ground water pumpage in the area.

The South Platte River is very similar to the North Platte and Platte Rivers in stream topography. It is a wide meandering green river with multi-channels and many islands. The land is green near the river and brown elsewhere.

The cattle feedlots at Greeley, Colorado are among the largest in the world. There is definite evidence of increases in algae in the stream below Greeley.

The chief source of recharge to the valley-fill aquifers is from river water delivered to the irrigated lands and resulting mineral and nutrient seepage from farms, canals, and reservoirs. The oil and gas fields produce saline waste waters which are held or stored in unlined pits. Seepage from these pits is adversely affecting the quality of water in unconfined aquifers.

Widespread pollution by ABS exists in the valley-fill aquifers in the upper part of the main South Platte River Valley and its southern tributary valleys. The principle source of ABS is sewage-laden recharge from the South Platte River; a major part of the sewage treatment plant effluents originating in the Denver Metropolitan area. Septic tanks also contribute ABS to unconfined aquifers. Manufacture of ABS was discontinued in 1965, but ABS pollution will continue in the shallow aquifers for several decades. Nitrates are contributed by fertilizers, sewage plant effluents, and feedlots.

North Platte River Basin

Forty-three percent of the population of this basin is concentrated in Casper, Wyoming. Economic activity is about equally divided among agriculture, manufacturing, mining, and construction. The major oxygen-demanding pollutants originate in population centers.

There is an oil field and a number of processing plants in the Casper, Wyoming section of the stream which contribute wastes to the stream in places. There also are alkali ponds in this section.

In the area of the North Platte River between Torrington, Wyoming and Bridgeport, Nebraska, the sources of pollution are municipalities and beet sugar plants. The pollution load of the river fluctuates with the beet sugar crops. Although most of the plants have constructed holding ponds, levee failures are frequent.

Many areas which were badly polluted have made efforts to clean up. There are many recently constructed pollution control facilities. There are many cattle feedlots throughout the basin. Some of these feedlots have good pollution control whereas others have none at all.

There are sections of the river as it passes through Wyoming which are very turbid. In some of the reservoirs, there is evidence of phosphates which have increased the plankton content of the stream.

There are diversions for irrigation and reservoirs for irrigation storage flows. These increase the mineralization and silting of the water in return flows to the stream.

The river contains many islands covered with vegetation. The treelined banks and the area close to the stream are green. The land otherwise is very brown with sparse vegetation. There are many new oxidation lagoons in evidence which have heavy algae covers. There is much available low-cost land to support this economical method of treatment. The headwaters section in Colorado is devoted to small ranches and resorts. It drains a valley at the edge of the Rocky Mountains.

Niobrara River Basin

This river is included among those protected by the "Wild Rivers" Act. It is navigable only by canoe or similar craft. In this basin, agriculture and agricultural industry service are the primary economic activities. The largest population center contains only 12% of the total basin population. The major pollutants are contributed by irrigation return flows and feedlot runoff and include soil minerals, fertilizers, pesticides, plant and animal wastes, and bacteria. The area near the mouth is farmed whereas the area in the headwaters contains many cattle ranches. This stream is shallow with built up islands. Many of the bridges are protected at their bases by abandoned cars and tires which are held in place by steel cables.

Interstate Water Quality Standards

Missouri River

With the borders of the State of Missouri.

Missouri

Interstate Water Quality Standards for the Missouri River from its mouth to the Missouri-Kansas State Line (River Mile 367.5).

Public Water Supply

Bacteria - Fecal Coliform: MPN shall be less than 2,000/100 ml.

Dissolved Oxygen - Shall not be less than 4 mg/l.

Temperature - Shall be less than 90°F. The temperature of the stream shall not be increased or decreased more than 5°F.

pH - Shall be between 6.5 and 9.0.

Oil and Grease - Virtually free of oil and grease.

Solids - No noticeable man-made deposits of organic solids. Free of floating debris, scum, etc., in amounts sufficient to be unsightly.

Taste and Odor Producing Substances - Shall be limited to concentrations in the stream that will not interfere with the production of potable water, or impart unpalatable flavor to food fish.

Color - No color of other than natural origin that will cause substantial visible contrast with the natural appearance of the stream.

Toxic or Detrimental Substances - Shall be limited to non-toxic or non-detrimental concentrations in the stream.

Radioactive Material - Radium-226 shall not be greater than 3 picocuries/l, Strontium-90 shall not be greater than 10 picocuries/l; gross beta concentration (in absence of Sr-90 and alpha emitters) shall not be greater than 1,000 pc/l.

Fluorides - Soluble fluoride less than 1.2 mg/l.

Missouri River

Between the States of Kansas and Missouri.

Missouri

Interstate Water Quality Standards for the Missouri River between River Mile 367.5 and 489.7 are the same as those found on page 278 of this report.

Kansas

Interstate Water Quality Standards for the Missouri River Between River Mile 367.5 and 489.7.

Public Water Supply

Bacteria - Drinking Water: MPN shall be less than 20,000/100 ml. Body Contact: MPN shall be less than 1,000/100 ml.

Dissolved Oxygen - Shall not be less than 4 mg/l.

Temperature - Shall be less than 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Essentially free of visible oil and grease.

Solids - No man-made deposits of solids in the river. Free of floating debris, scum, and other floating materials.

Turbidity - No visible turbidity increase, of other than natural origin.

Taste and Odor Producing Substances - Shall be limited to concentrations in the river that will not interfere with the production of potable water or impart unpalatable flavor to fish.

Color - Shall be limited to concentrations which will not be detrimental.

Missouri River

Between the States of Missouri and Nebraska.

Missouri

Interstate Water Quality Standards for the Missouri River Between River Mile 489.7 and 552.8 are the same as those found on page 278 of this report.

Nebraska

Interstate Water Quality Standards for the Missouri River Between River Mile 489.7 to 552.8 are Class A.

Domestic Water Supply - Class A

pH - The pH shall be between 6.5 and 9.0 and shall not be changed more than 1.0 unit.

Dissolved Oxygen - Shall be 5.0 mg/l or greater.

Temperature - Allowable change 5°F, May through October; 10°F, November through April. Maximum limit 90°F, maximum rate of change limited to 2° per hour.

Toxic or Detrimental Substances - None alone or in combination with other substances or wastes in concentration of such nature as to render the receiving water unsafe or unsuitable for the designated use. Raw water shall be of such quality that after treatment by coagulation, filtration, sedimentation, the water will meet Public Health Drinking Water Standards.

Ammonia nitrogen concentrations shall not exceed 3.5 mg/l in warm water streams where the pH in these streams does not exceed a pH value of 8.3. If the pH of a stream exceeds 8.3, the undissociated ammonium hydroxide as nitrogen shall not exceed 0.25 mg/l in warm water streams.

For irrigation use, the boron concentration shall not exceed 0.75 mg/l.

For toxic materials not specified bioassay methods acceptable to Nebraska Water Pollution Control Council and FWPCA will be used.

Bacteria - Coliform group and fecal coliform organisms shall not exceed a geometric mean of 10,000 total, or 2,000 fecal coliform bacteria per 100 ml, based on at least 5 samples per 30 day period. No more than 20% of samples shall exceed 20,000 total, or 4,000 fecal coliform bacteria.

Taste and Odor Producing Substances - Concentration of substances shall be less than that amount which would degrade the water quality for the designated use. Phenols concentration shall not exceed 0.001 mg/l.

Shall not contain concentrations of substances which will render an undesirable taste to fish flesh, or in any other way make such fish flesh inedible.

Color - No evidence of matter that creates nuisance conditions or is offensive to the senses of sight, touch, smell, or taste, including color.

Oil and Grease - No residue attributable to waste water or visible film of oil or globules of grease shall be present.

Solids - None from wastewater sources which will permit objectionable deposition or be deleterious for the designated uses. In no case shall turbidity caused by waste water impart more than a 10% increase in turbidity to the receiving water.

TDS shall be less than 600 mg/l and shall not be changed more than 10%.

Radioactive Material - Radiological limits shall be in accordance with the Radiological Health Regulations, 1st edition, State of Nebraska, 1966.

Missouri River

Between the States of Nebraska and Iowa.

Nebraska

Interstate Water Quality Standards (Class A) for the Missouri River Between River Mile 552.8 and River Mile 734.1 are the same as those found on pages 280 to 281 of this report.

Iowa

Interstate Water Quality Standards for the Missouri River Between River Mile 552.8 and River Mile 734.1 are as follows:

Public Water Supply

Bacteria - Sanitary survey indicates no presence of sewage. Bacteriological survey using coliform or other indices indicates concentrations no higher than those normally found in these waters when free from pollution by sewage.

Radioactive Substances - Beta activity (in absence of Sr-90 and alpha activity) shall be less than 1,000 micromicrocuries/l.

Chemical Constituents

Constituent	Concentration (mg/l)
Arsenic	Shall be less than 0.05 mg/l
Barium	Shall be less than 1.0 mg/l
Cadmium	Shall be less than 0.0 mg/l
Chromium (hexavalent)	Shall be less than 0.05 mg/l
Fluoride	Shall be less than 2.0 mg/l
Lead	Shall be less than 0.05 mg/l
Phenols	Shall be less than 0.001 mg/l

Aquatic Life

Toxic and Deleterious Substances - All substances toxic or detrimental to aquatic life shall be limited to non-toxic or non-detrimental concentrations in the surface water.

Chemical Constituents

Constituent	Concentration mg/l
Ammonia nitrate	Shall be less than 2.0
Arsenic	Shall be less than 1.0
Barium	Shall be less than 5.0
Cadmium	Shall be less than 0.05
Chromium (hexavalent)	Shall be less than 0.05
Chromium (trivalent)	Shall be less than 1.0
Copper	Shall be less than 0.02
Cyanide	Shall be less than 0.025
Lead	Shall be less than 0.10
Phenols	Shall be less than 0.20

Constituent	Concentration mg/l
Zinc	Shall be less than 1.0
Heavy Metals	Shall be less than 5.0
Temperature	Shall be less than 93°F (May - November) shall be less than 73°F (December - April)

Dissolved Oxygen - Shall be more than 5 mg/l during 16 hr./24 hr. period, shall not be less than 4 mg/l in any sample.

pH - The pH shall be between 6.8 and 9.0

Missouri River

Between the States of Nebraska and South Dakota.

Nebraska

Interstate Water Quality Standards (Class A) for the Missouri River Between River Mile 734.1 and the Gavins Point Dam are the same as those found on pages 280 to 281 of this report.

South Dakota

Interstate Water Quality Standards for the Missouri River Between River Mile 734.1 and the Gavins Point Dam are as follows:

Domestic Water Supply and Other Water Uses

Bacteria - MPN shall be less than 1,000/100 ml as a monthly mean average, shall be less than 2,400/100 for any sample.

Dissolved Oxygen - Shall not be less than 4 mg/l.

pH - the pH shall be between 6.5 and 8.8 and shall not be changed more than 1.0 unit.

Turbidity - Shall be less than 50 J.C.U.

Temperature - Shall be less than 85°F. The temperature of the stream shall not be increased or decreased more than 4°F.

Dissolved Solids - Shall be less than 1,000 mg/l.

Visible Pollution - No wastes shall be discharged which produce floating solids, scum, oil slicks, material discoloration, undesirable odors, visible gassing, sludge deposits, slimes, fungus growth, etc.

Suspended Solids - Shall be less than 90 mg/l.

Toxic Materials - No materials shall be discharged which produce concentrations of chemicals toxic or humans, animals, or the most sensitive stage or form of aquatic life greater than 0.1 times the 96-hour TL_m for short residual compounds or 0.01 times the 96-hour TL_m for accumulative substances.

Radioactive Material - Shall not be permitted in the stream unless these materials are readily soluble or dispersible.

Nitrates - Shall be less than 45 mg/l.

Alkalinity - Shall be less than 750 mg/l.

Cyanides - Shall be less than 0.02 mg/l.

Hydrogen Sulfide - Shall be less than 0.5 mg/l.

Iron - Total Iron - Shall be less than 0.2 mg/l.

Marais des Cygnes River

At the Missouri-Kansas State Line.

Missouri

Interstate Water Quality Standards for the Osage and Marais des Cygnes Rivers from the Mouth at the Missouri River to the Missouri-Kansas State Line.

Public Water Supply

Bacteria - Fecal coliform shall not exceed 200/100 ml (either MPN or MF). Not more than 10% of the total samples in a month should exceed 400/100 ml (MPN or MF).

Dissolved Oxygen - Shall not be less than 5 mg/l.

Temperature - Shall not be greater than 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Virtually free of oil and grease.

Solids - a) No noticeable man-made deposits of either organic or inorganic solids on the stream bed. b) Free of floating debris, scum, etc., in amounts sufficient to be unsightly.

Taste and Odor Producing Substances - Shall be limited to concentrations in the stream that will not interfere with the production of potable water or impart unpalatable flavor to food fish.

Turbidity - No turbidity of other than natural origin that will cause substantial visible contrast with the natural appearance of the stream.

Color - No color of other than natural origin that will cause substantial visible contrast with the natural appearance of the stream.

Toxic or Detrimental Substances - Shall be limited to non-toxic or non-detrimental concentrations in the stream.

Radioactive Material - Radium-226 shall not be greater than 3 pico curies/l. Strontium-90 shall not be greater than 10 pico curies/l gross beta concentrations (in absence of Sr-90 and alpha emitters) shall not be greater than 1,000 pc/l.

Fluorides - Soluble fluoride shall not be greater than 1.2 mg/l.

Kansas

Interstate Water Quality Standards for the Marais des Crygnes River.

Public Water Supply

Bacteria - a) Drinking water: MPN shall not be greater than 20,000/100 ml. b) Body contact: MPN shall not be greater than 1,000/100 ml.

Dissolved Oxygen - Shall be less than 5 mg/l.

Temperature - Shall be greater than 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Essentially free of visible oil and grease.

Solids - a) No man-made deposits of solids. b) Free of floating debris, scum, and other floating materials.

Taste and Odor Producing Substances - Shall be limited to concentrations in the river that will not interfere with the production of potable water or impart unpalatable flavor to fish.

Turbidity - No visible turbidity increase of other than natural origin.

Color - Shall be limited to concentrations which will not be detrimental.

Kansas River

All of which is within the State of Kansas.

Kansas

Interstate Water Quality Standards for the Kansas River from its Mouth at the Missouri River to the Confluence of the Republican and the Smokey Hill Rivers.

Public Water Supply, etc.

Bacteria - Drinking water: MPN shall not be greater than 20,000/100 ml. Body contact: MPN shall not be greater than 1,000/100 ml.

Dissolved Oxygen - DO shall be 5 mg/l or above.

Temperature - Temperature shall not be above 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Essentially free of visible oil and grease.

Solids - No man-made deposits of solids in the river. Free of floating debris, scum, and other floating materials.

Turbidity - No visible turbidity increase, of other than natural origin.

Taste and Odor Producing Substances - Shall be limited to concentrations in the river that will not interfere with the production of potable water or impart unpalatable flavor to fish.

Color - Shall be limited to concentrations which will not be detrimental.

Smokey Hill River

Within the State of Kansas.

Kansas

Interstate Water Quality Standards for the Smokey Hill River within Kansas.

Public Water Supply

Bacteria - Drinking water MPN shall be less than 20,000/100 ml. Body contact MPN shall be less than 1,000/100 ml.

Dissolved Oxygen - Shall be 5 mg/l or greater.

Temperature - Shall be less than 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Essentially free of visible oil and grease.

Solids - No man-made deposits of solids. Free of floating debris, scum, and other floating materials.

Taste and Odor Producing Substances - Shall be limited to concentrations in the river that will not interfere with the production of potable water or impart unpalatable flavor to fish.

Turbidity - No visible turbidity increase of other than natural origin.

Color - Shall be limited to concentrations which will not be detrimental.

Lower Republican River

At the Kansas-Nebraska State Line near Hardy, Nebraska.

Kansas

Interstate Water Quality Standards for the Lower Republican River from its Mouth at the Kansas River to the Kansas-Nebraska State Line.

Public Water Supply

Bacteria - Drinking water shall be less than 20,000/100 ml. Body contact shall be less than 1,000/100 ml.

Dissolved Oxygen - Shall be greater than 5 mg/l.

Temperature - Shall be less than 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Essentially free of visible oil and grease.

Solids - No man-made deposits of solids in the river. Free of floating debris, scum, and other floating materials.

Turbidity - No visible turbidity increase of other than natural origin.

Taste and Odor Producing Substances - Shall be limited to concentrations in the river that will not interfere with the production of potable water, or impart unpalatable flavor to fish.

Color - Shall be limited to concentrations which will not be detrimental.

Nebraska

Interstate Water Quality Standards (Class "C") for the Republican River as it flows within Nebraska.

Agricultural, Industrial, etc.

Bacteria - Coliform group and fecal coliform organisms shall not exceed a geometric mean 10,000 total or 2,000 fecal coliform bacteria per 100 ml, based on at least 5 samples per 30 day period. No more than 20% of samples shall exceed 20,000 total or 4,000 fecal coliform bacteria.

Dissolved Oxygen - Oxygen consuming waste shall not lower the dissolved oxygen in the receiving stream lower than 5 mg/l in warm water streams and 6 mg/l in a trout stream.

Temperature - Allowable change 5°F, May through October; 10°F, November through April. Maximum limit 90°F, maximum rate of change limited to 2° per hour.

pH - Hydrogen ion concentrations expressed as pH shall be maintained between 6.5 and 9.0 with a maximum total change of 1.0 pH unit from the value in the receiving stream.

Oil and Grease - No residue attributable to wastewater or visible film of oil or gloubles of grease shall be present.

Solids - A point source discharge shall not increase the total dissolved solids concentration of a receiving water by more than 20%, this value shall not exceed 100 mg/l, and in no case shall the total dissolved solids of a stream exceed 1,500 mg/l. For irrigation use, the SAR value and conductivity shall not be greater than a C3-S2 class irrigation water as shown in Figure 25 of Agricultural Handbook 60.

Turbidity - None from wastewater sources which will permit objectionable deposition or be deleterious for the designated uses. In no case shall turbidity caused by wastewater impart more than a 10% increase in turbidity to the receiving water.

Taste and Odor Producing Substances - Concentration of substances shall be less than that amount which would degrade the water quality for the designated use. Phenols concentration shall not exceed 0.001 mg/l. Shall not contain concentration of substances which will render an undesirable taste to fish flesh, or in any other way make such fish flesh inedible.

Aesthetic Considerations - No evidence of matter that creates nuisance conditions or is offensive to the senses of sight, touch, smell, or taste, including color.

Toxic and Deleterious Substances - None alone or in combination with other substances or wastes in concentration of such nature as to render the receiving water unsafe or unsuitable for the designated use. Raw water shall be of such quality that after treatment by coagulation, filtration, sedimentation, the water will meet Public Health Drinking Water Standards. Radiological limits shall be in accordance with the Radiological Health Regulations, 1st Edition, State of Nebraska, 1966. Ammonia nitrogen concentrations shall not exceed 3.5 mg/l in warm water streams where the pH in these streams does not exceed a pH value of 8.3. If the pH of a stream exceeds 8.3, the undissociated ammonium hydroxide as nitrogen shall not exceed 0.25 mg/l in warm water streams. For irrigation use, the boron concentration shall not exceed 0.75 mg/l. For toxic materials not specified bioassay methods acceptable to Nebraska Water Pollution Control Council and FWPCA will be used.

Upper Republican River

At the Nebraska-Kansas State Line near Benkelman, Nebraska.

Nebraska

Interstate Water Quality Standards (Class "C") for the Republican River as it flows within Nebraska can be found on pages 289 to 290 of this report.

Kansas

Interstate Water Quality Standards for the Upper Republican River as it flows from the Nebraska-Kansas State Line to the Kansas-Colorado State Line.

Agricultural, Aquatic Life

Bacteria - MPN shall not b[illegible]eater than 1,000/100 ml.

Temperature - Shall not b[illegible]e 90°F.

pH - Shall be between 6.[illegible].5.

Oil and Grease - Essentially free of visible oil and grease.

Solids - No man-made deposits of solids in the river. Free of floating debris, scum, and other floating materials.

Turbidity - No turbidity other than natural origin.

Taste and Odor Producing Substances - Shall be limited to concentrations in the receiving water that will not interfere with the production of potable water or impart unpalatable flavor to fish.

Upper Republican River

At the Kansas-Colorado State Line.

Kansas

Interstate Water Quality Standards for the Upper Republican River as it flows to the Kansas-Colorado State Line are found on page 290 of this report.

Colorado

Interstate Water Quality Standards for the Republican River from the Kansas-Colorado State Line to its Source.

Fish and Wildlife, Irrigation

Temperature - Shall be less than 90°F.

pH - Shall be between 6.5 and 8.5.

Oil and Grease - Free from floating debris, oil, grease, scum, etc.

Solids - Shall not exceed 3,000 mg/l.

Turbidity - No turbidity in concentration that will impair natural or developed fisheries.

Taste and Odor Producing Substances - Free from materials attributable to controllable sources that will produce off-flavor in the flesh of fish.

Dissolved Oxygen - Shall not be less than 5 mg/l.

Toxic Material - Free from biocides, toxic, or other deleterious substances attributable to controllable sources in concentrations or combinations which are harmful to aquatic life and crop life.

Platte River

Within the State of Nebraska.

Nebraska

Interstation Water Quality Standards for the Platte River to the Confluence of the North Platte and the South Platte Rivers can be found on pages 289 to 290 of this report.

South Platte River

At the Nebraska-Colorado State Line.

Nebraska

Interstate Water Quality Standards for the South Platte River from the Mouth at the Platte River to the Nebraska-Colorado State Line.

Industrial, Irrigation

Dissolved Oxygen - D.O. shall be 5 mg/l or greater.

pH - The pH shall be between 6.5 and 9.0 and shall not be changed more than 1.0 unit.

Turbidity - None from wastewater sources which will permit objectionable deposition or be deleterious for the designated uses. In no case shall turbidity caused by wastewater impart more than a 10% increase in turbidity to the receiving water.

Temperature - Allowable change 5°F, May through October; 10°F, November through April. Maximum limit 90°F; maximum rate of change limited to 2°F per hour.

Total Dissolved Solids - TDS shall not exceed 1,500 mg/l in the stream. TDS shall not be increased more than 20% or raised by 100 mg/l.

Toxic Material - None alone or in combination with other substances or wastes in concentration of such nature so as to render the receiving water unsafe or unsuitable for the designated use. Raw water shall be of such quality that after treatment by coagulation, filtration, sedimentation, the water will meet Public Health Drinking Water Standards. Radiological limits shall be in accordance with the Radiological Health Regulations, 1st Edition, State of Nebraska, 1966. Ammonia nitrogen concentrations shall not exceed 3.5 mg/l in warm water streams where the pH in these streams does not exceed a pH value of 8.3. If the pH of a stream exceeds 8.3, the undissociated ammonium hydroxide as nitrogen shall not exceed 0.25 mg/l in warm water streams. For irrigation use, the boron concentration shall not exceed 0.75 mg/l. For toxic materials not specified bioassay methods acceptable to Nebraska Water Pollution Control Council and FWPCA will be used.

Bacteria - Coliform group and fecal coliform organisms shall not exceed a geometric mean 10,000 total or 2,000 fecal coliform bacteria per 100 ml, based on at least 5 samples per 30 day period. No more than 20% of samples shall exceed 20,000 total of 4,000 fecal coliform bacteria.

Taste and Odor Producing Substances - Concentration of substances shall be less than that amount which would degrade the water quality for the designated use. Phenols concentration shall not exceed 0.001 mg/l. Shall not contain concentrations of substances which will render an undesirable taste to fish flesh, or in any other way make such fish flesh inedible.

Residue Oil and Floating Substances - No residue attributable to wastewater or visible film of oil or globules of grease shall be present.

Colorado

Interstate Water Quality Standards for the South Platte River at the Nebraska-Colorado State Line.

Fish and Wildlife (Warm Waters)

Dissolved Oxygen - Shall not be less than 5 mg/l.

pH - Shall be between 6.5 and 8.5.

Turbidity - No turbidity shall exist in concentrations that will impair natural and developed fisheries.

Temperature - Shall not be above 90°F.

Toxic Material - Free from biocides, toxic, or other deleterious substances attributable to controllable sources in concentrations or combinations which are harmful to aquatic life.

Taste and Odor Producing Substances - Free from materials attributable to controllable sources that will produce odor, in the water, or produce an appreciable change in the existing color, taste, turbidity.

Residue Oil and Floating Substances - Free from floating debris, oil, grease, scum, etc.

North Platte River

At the Nebraska-Wyoming State Line.

Nebraska

Interstate Water Quality Standards (Class "C") for the North Platte River from its Mouth at the Platte River to the Nebraska-Wyoming State Line can be found on pages 289 to 290 of this report.

Wyoming

Interstate Water Quality Standards for the North Platte River from the Nebraska-Wyoming State Line to the outlet of the Alcova Reservoir.

Settleable Solids - Essentially free from substances of other than natural origin that will settle to form sludge, bank or bottom deposits.

Floating Solids - Essentially free from floating debris, oil, grease, scum, and other floating materials of other than natural origin in amounts sufficient to be unsightly.

Taste, Odor, Color - Essentially free from substances of other than natural origin which produce taste, odor, or color that would: a) impart an unpalatable or off-flavor in fish flesh. b) visibly after the natural color of the water, or impart color to skin, clothing, vessels, or structures. c) produce detectable odor at the site of use. d) through interaction with chemicals used in the existing water treatment process, result in undesirable taste or odor of the finished water.

Toxic, Radioactive - Water quality will be such that after conventional water treatment the treated water will meet Public Health Service Drinking Water Standards.

Turbidity - (a) When turbidity is 150 units or less, increase in turbidity shall not be greater than 15 units. (b) When turbidity is greater than 150 units, increase in turbidity shall not be greater than 10%.

Dissolved Oxygen - Shall be 6 mg/l or greater.

Temperature - (a) When temperature is 70°F or less, increase in temperature shall not be greater than 2°F. (b) When temperature is greater 70°F increase in temperature shall not be greater 4°F.

Bacteria - MPN shall be less than 240/100 ml as a geometric mean of the last five consecutive samples; MPN shall be less than 750/100 ml any sample.

pH - The pH shall be between 6.5 and 8.5.

North Platte River

At the Wyoming-Colorado State Line.

Wyoming

Interstate Water Quality Standards for the North Platte River from the Bridge on Highway No. 87 at Douglas, Wyoming to the Wyoming-Colorado State Line as the same as those listed on pages 295 of this report.

Colorado

Interstate Water Quality Standards for the North Platte River from the Wyoming-Colorado State Line to its source.

Fish and Wildlife (Cold Water)

Settleable Solids - Free from substances attributable to controllable sources that will settle to form bottom deposits.

Floating Solids - Free from unsightly floating debris, oil, grease, scum, etc., attributable to controllable sources.

Taste, Odor, Color - Free from materials attributable to controllable sources that will produce off-flavor in the flesh of fish, or produce an appreciable change in the existing color, taste turbidity of the water.

Toxic, Radioactive - Free from biocides, toxic, or other deleterious substances attributable to controllable sources in concentrations harmful to aquatic life.

Turbidity - No turbidity shall exist in concentrations that will impair natural and developed fisheries.

Dissolved Oxygen - Shall not be less than 6 mg/l.

Temperature - Shall not be greater than 70°F.

pH - The pH shall be between 6.5 and 8.5.

Niobrara River

Between the States of Nebraska and Wyoming.

Nebraska

Interstate Water Quality Standards (Class A, Trout Fishing) for the Niobrara River are from its mouth at the Missouri River to the Nebraska-Wyoming State Line.

Domestic Water Supply, Trout Fishing

Settleable Solids - None from wastewater sources which will permit objectionable deposition or be deleterious for the designated uses. In no case shall turbidity caused by wastewater impart more than a 10% increase in turbidity to the receiving water.

Floating Solids - No residue attributable to wastewater or visible film of oil or globules of grease shall be present.

Taste, Odor, Color - Concentration of substances shall be less than the amount which would degrade the water quality for the designated use. Phenols concentration shall not exceed 0.001 mg/l. Shall not contain concentrations of substances which will render an undesirable taste to fish, flesh, or in any other way make such fish flesh inedible. No evidence of matter that creates nuisance conditions or is offensive to the senses of sight, touch, smell, or taste, including color.

Toxic Radioactive - None alone or in combination with other substances or wastes in concentration of such nature so as to render the receiving water unsafe or unsuitable for the designated use. Raw water shall be of such quality that after treatment by coagulation, filtration, sedimentation, the water will meet Public Health Drinking Water Standards. Radiological limits shall be in accordance with the Radiological Health Regulations, 1st Edition, State of Nebraska, 1966. Ammonia nitrogen concentrations shall not exceed 1.4 mg/l in trout streams where the pH in these streams does not exceed a pH value of 8.3. If the pH of a stream exceeds 8.3, the undissociated ammonium hydroxide as nitrogen shall not exceed one-tenth mg/l in trout streams. For irrigation use, the boron concentration shall not exceed 0.75 mg/l. For toxic materials not specified bioassay methods acceptable to Nebraska Water Pollution Control County and FWPCA will be used.

Turbidity - Increase in turbidity shall not be greater than 10%.

Dissolved Oxygen - Shall be greater than 6 mg/l.

Temperature - Allowable change 5°F, maximum limit 65°F, maximum rate of change limited to 2° per hour.

Bacteria - Coliform group and fecal coliform organisms shall not exceed a geometric mean 10,000 total or 2,000 fecal coliform bacteria per 100 ml, based on at least 5 samples per 30 day period. No more than 20% of samples shall exceed 20,000 total or 4,000 fecal coliform bacteria.

pH - The pH shall be between 6.5 and 9.0 and shall not be changed more than 1.0.

Total Dissolved Solids - A point source discharge shall not increase the total dissolved solids concentration of a receiving water by more than 20%, and in no case shall the total dissolved solids of a stream exceed 600 mg/l. For irrigation use the SAR value and conductivity shall not be greater than a C3-S2 class irrigation water as shown in Figure 25 of Agricultural Handbook 60.

Wyoming

Interstate Water Quality Standards are listed and applied here to the Niobrara River. This stream in Wyoming is considered an intermittent stream.

Domestic Water Supply, Trout Fishing

Settleable Solids - Essentially free from substances of other than natural origin that will settle to form sludge, bank or bottom deposits.

Floating Solids - Essentially free from floating debris, oil, grease, scum, and other floating materials of other than natural origin in amounts sufficient to be unsightly.

Taste, Odor, Color - Essentially free from substances of other than natural origin which produce taste, odor, or color that would: a) impart an unpalatable or off-flavor in fish flesh; b) visibly after the natural color of the water, or impart color to skin, clothing, vessels, or structures; c) produce detectable odor at the site of use;

d) through interaction with chemicals used in the existing water treatment process, result in undesirable taste or odor of the finished water.

Toxic, Radioactive - Water quality will be such that after conventional water treatment the treated water will meet Public Health Service Drinking Water Standards.

Turbidity - (a) When turbidity is 150 units or less, increase in temperature shall not be greater than 15 units. (b) When temperature is greater than 150 units, increase in temperature shall not be greater than 10%.

Dissolved Oxygen - Shall be 6 mg/l or greater.

Temperature - (a) When temperature is 70°F or less, increase in temperature shall not be greater than 2°F. (b) When temperature is greater than 70°F increase in temperature shall not be greater than 4°F.

Bacteria - MPN shall not be less than 2,000/100 ml as a geometric mean of the last five consecutive samples; no sample shall exceed the 95% confidence limit of historical average.

pH - The pH shall be between 6.5 and 8.5.

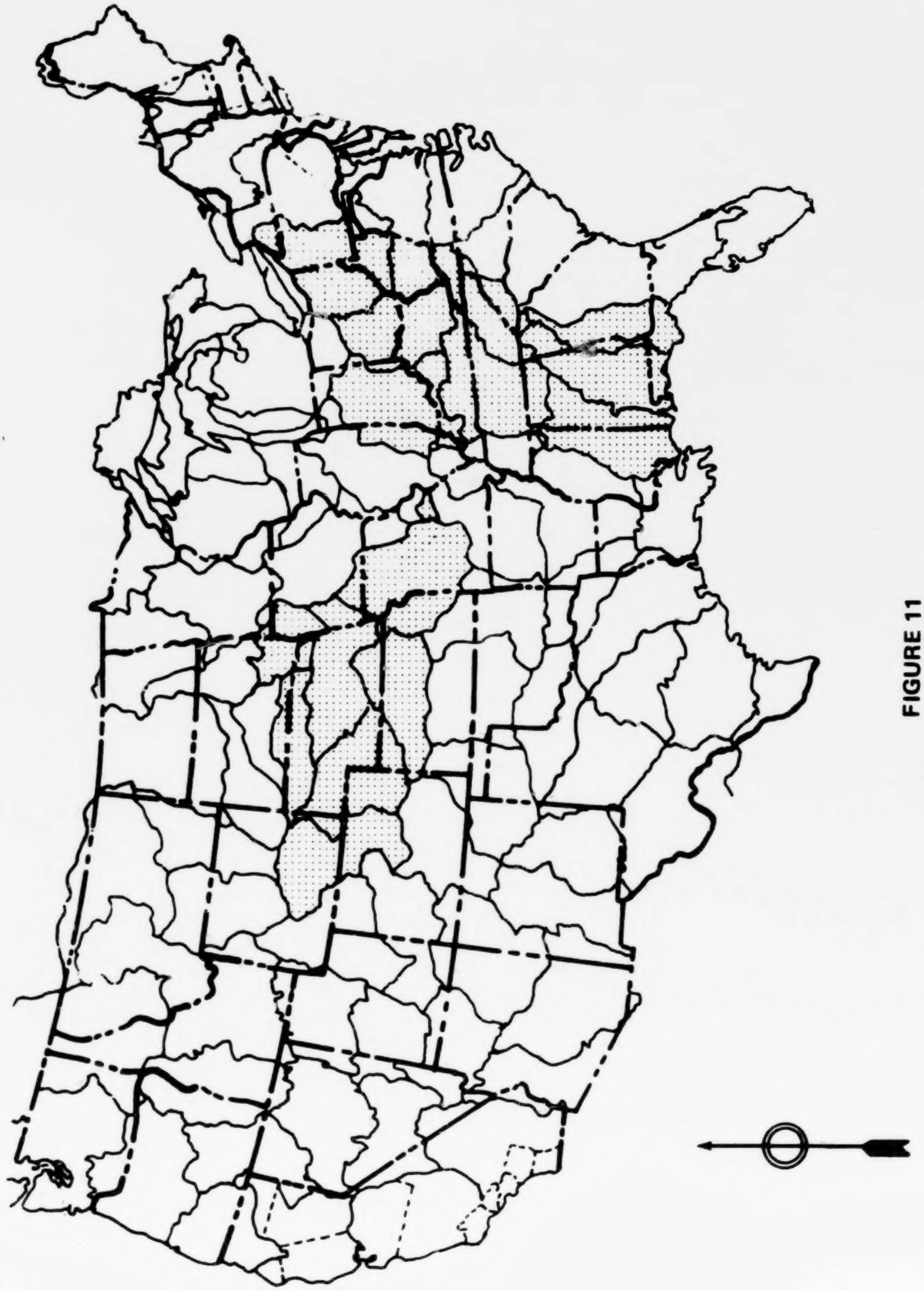
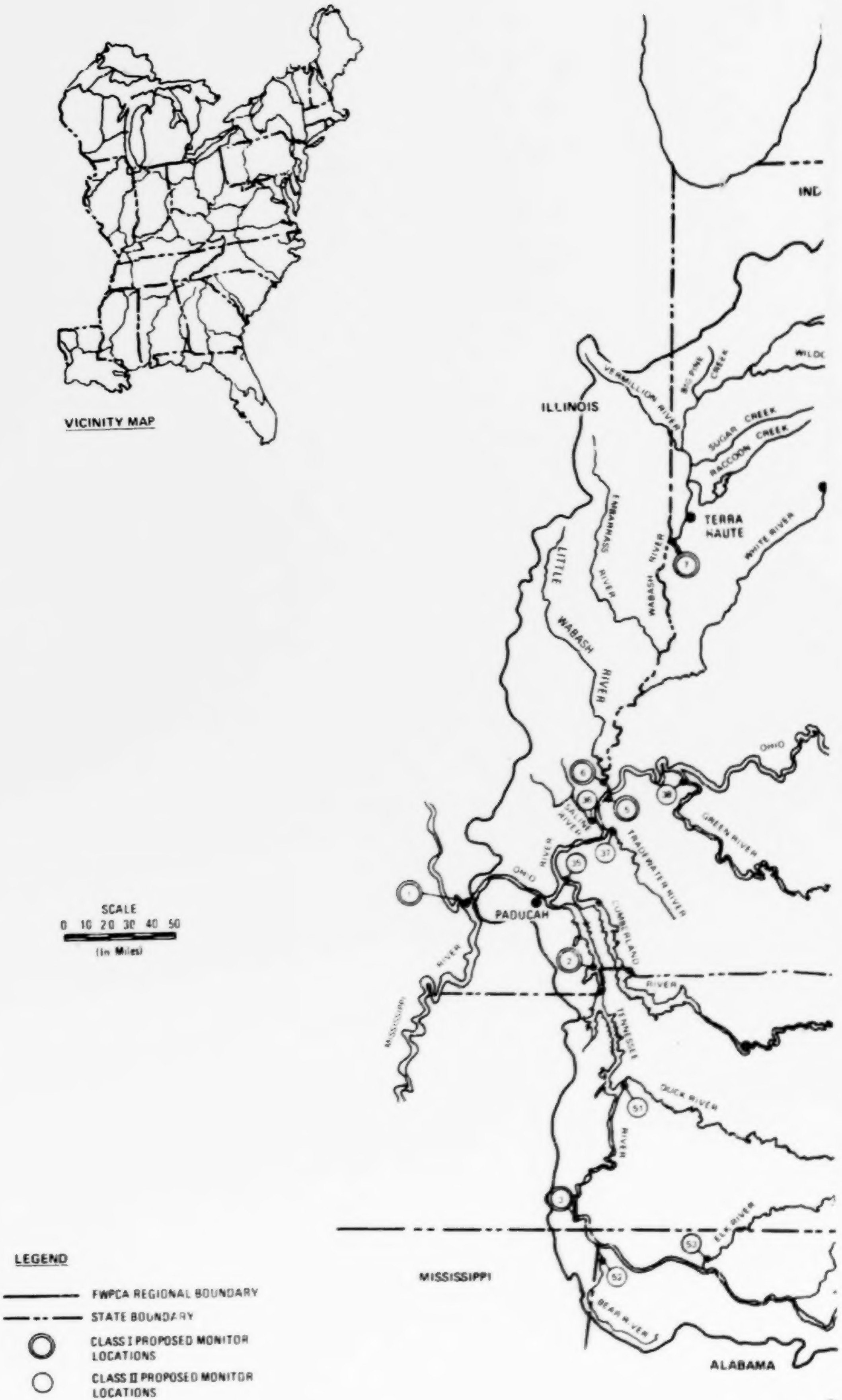
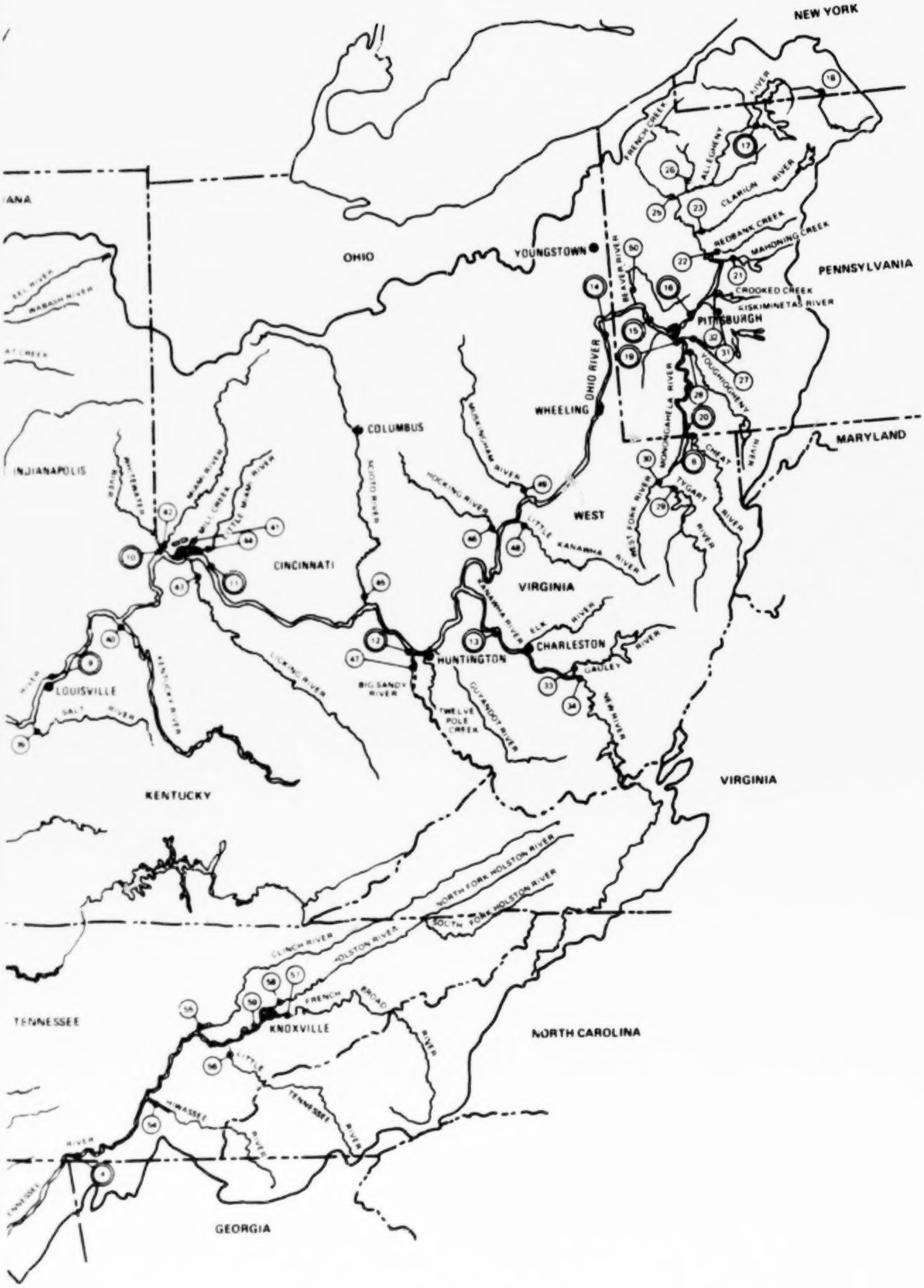


FIGURE 11
MAP OF THE STUDY AREA

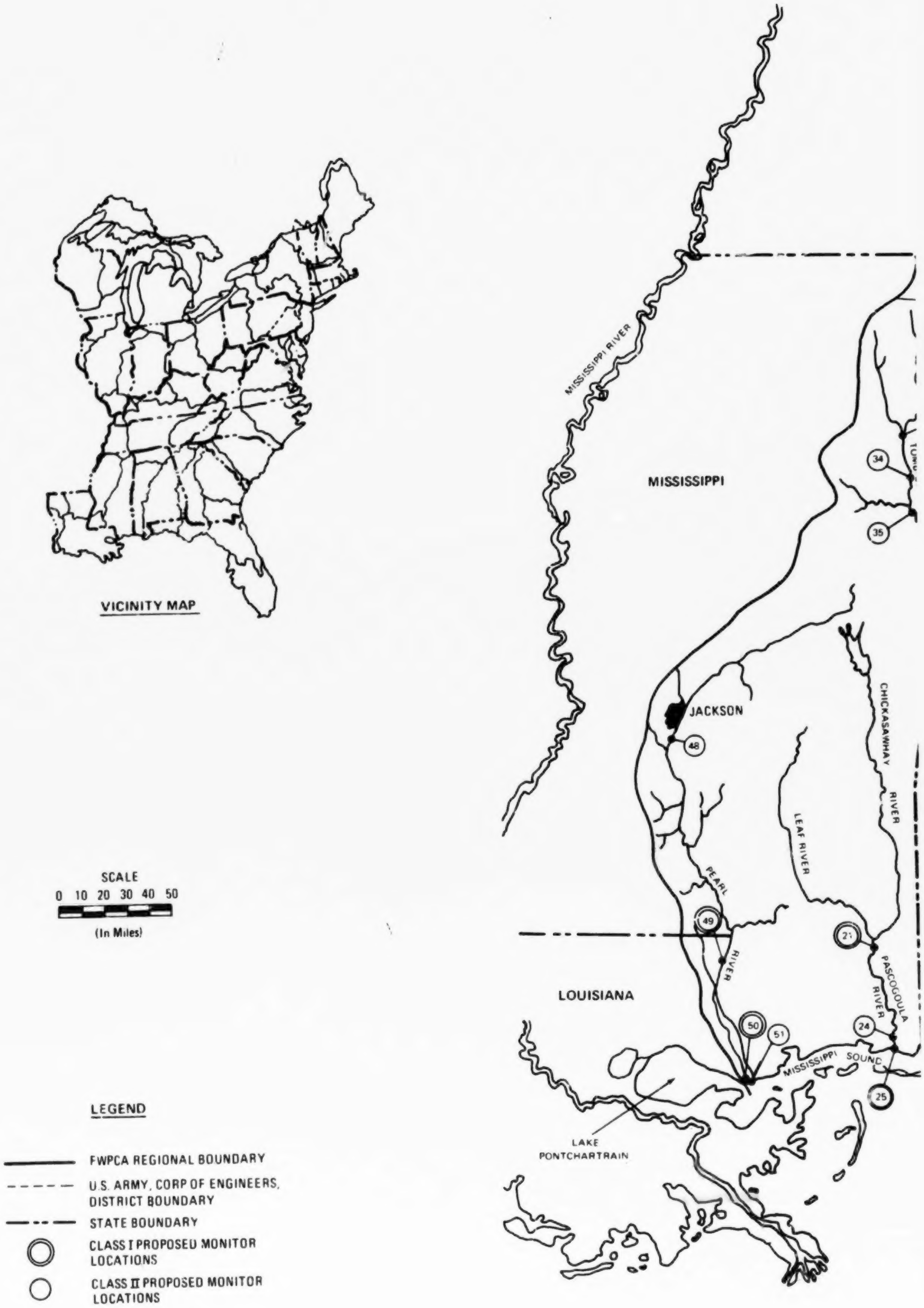

VICINITY MAP
SCALE
0 10 20 30 40 50
(In Miles)
LEGEND
FWPCA REGIONAL BOUNDARY
STATE BOUNDARY
CLASS I PROPOSED MONITOR LOCATIONS
CLASS II PROPOSED MONITOR LOCATIONS
IND
ILLINOIS
VERMILLION RIVER
BIG PINE CREEK
WILDC
SUGAR CREEK
RACCOON CREEK
TERRA HAUTE
EMBARRASS RIVER
WABASH RIVER
WHITE RIVER
LITTLE WABASH RIVER
OHIO
GREEN RIVER
SALINE RIVER
TRADEWATER RIVER
OHIO RIVER
PADUCAH
CUMBERLAND RIVER
MISSISSIPPI RIVER
TENNESSEE RIVER
DUCK RIVER
ELK RIVER
BEAR RIVER
MISSISSIPPI
ALABAMA
7
6
36
5
38
35
37
1
2
51
3
53
52

FI
OHIO AND TE

A


NEW YORK
PENNSYLVANIA
ANA
OHIO
YOUNGSTOWN
PITTSBURGH
WHEELING
COLUMBUS
CINCINNATI
INDIANAPOLIS
LOUISVILLE
KENTUCKY
WEST
VIRGINIA
VIRGINIA
MARYLAND
HUNTINGTON
CHARLESTON
KNOXVILLE
TENNESSEE
NORTH CAROLINA
GEORGIA
FRENCH CREEK
ALLEGHENY RIVER
CLARION RIVER
REDBANK CREEK
MAHONING CREEK
CROOKED CREEK
KISKIMINETAS RIVER
BEAVER RIVER
OHIO RIVER
MONONGAHELA RIVER
YOUGHIOGHENY
CHEAT
TYGART
RIVER
WEST FORK RIVER
LITTLE KANAWHA RIVER
MUSKINGUM RIVER
HOCKING RIVER
SCIOTO RIVER
MIAMI RIVER
LITTLE MIAMI RIVER
MILL CREEK
WHITEWATER
WABASH RIVER
EEL RIVER
KANAWHA RIVER
ELK RIVER
GAULEY RIVER
NEW RIVER
GUYANDOT RIVER
TWELVE POLE CREEK
BIG SANDY RIVER
LICKING RIVER
KENTUCKY RIVER
SALT RIVER
RIVER
NORTH FORK HOLSTON RIVER
SOUTH FORK HOLSTON RIVER
CLINCH RIVER
HOLSTON RIVER
FRENCH BROAD RIVER
LITTLE
TENNESSEE RIVER
HIWASSEE RIVER
RIVER
TENNESSEE
18
17
26
25
23
22
21
50
16
14
15
19
32
31
27
28
20
30
6
29
49
46
48
62
10
64
61
63
11
65
12
47
13
33
34
40
9
35
58
57
59
55
56
54
8

GURE 12
NNESSEE RIVER BASINS


VICINITY MAP
MISSISSIPPI RIVER
MISSISSIPPI
JACKSON
48
34
35
CHICKASAWHAY RIVER
LEAF RIVER
PEARL RIVER
49
21
PASCOGOULA RIVER
LOUISIANA
50
51
24
25
MISSISSIPPI SOUND
LAKE PONTCHARTRAIN
SCALE
0 10 20 30 40 50
(In Miles)
LEGEND
FWPCA REGIONAL BOUNDARY
U.S. ARMY, CORP OF ENGINEERS, DISTRICT BOUNDARY
STATE BOUNDARY
CLASS I PROPOSED MONITOR LOCATIONS
CLASS II PROPOSED MONITOR LOCATIONS

A

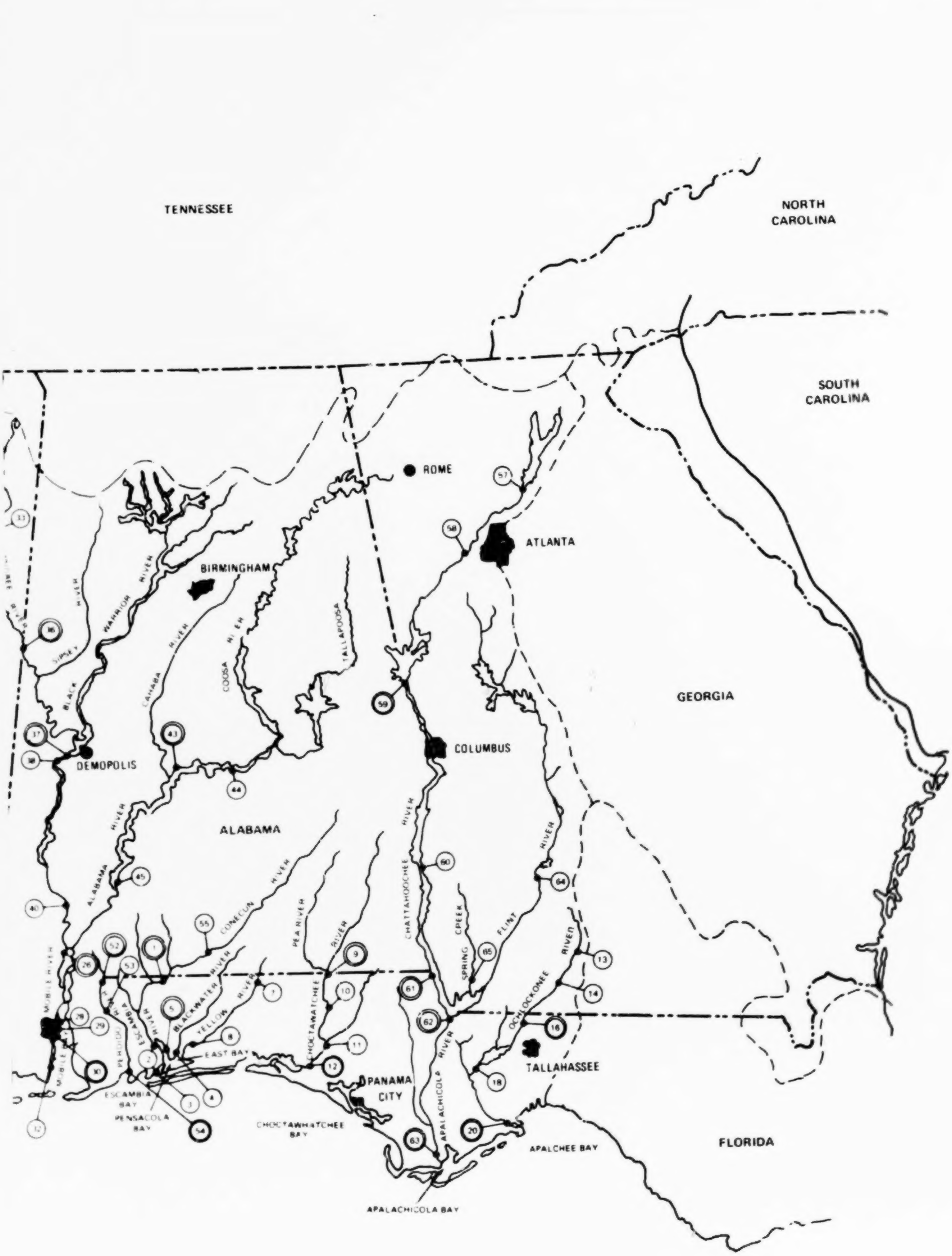
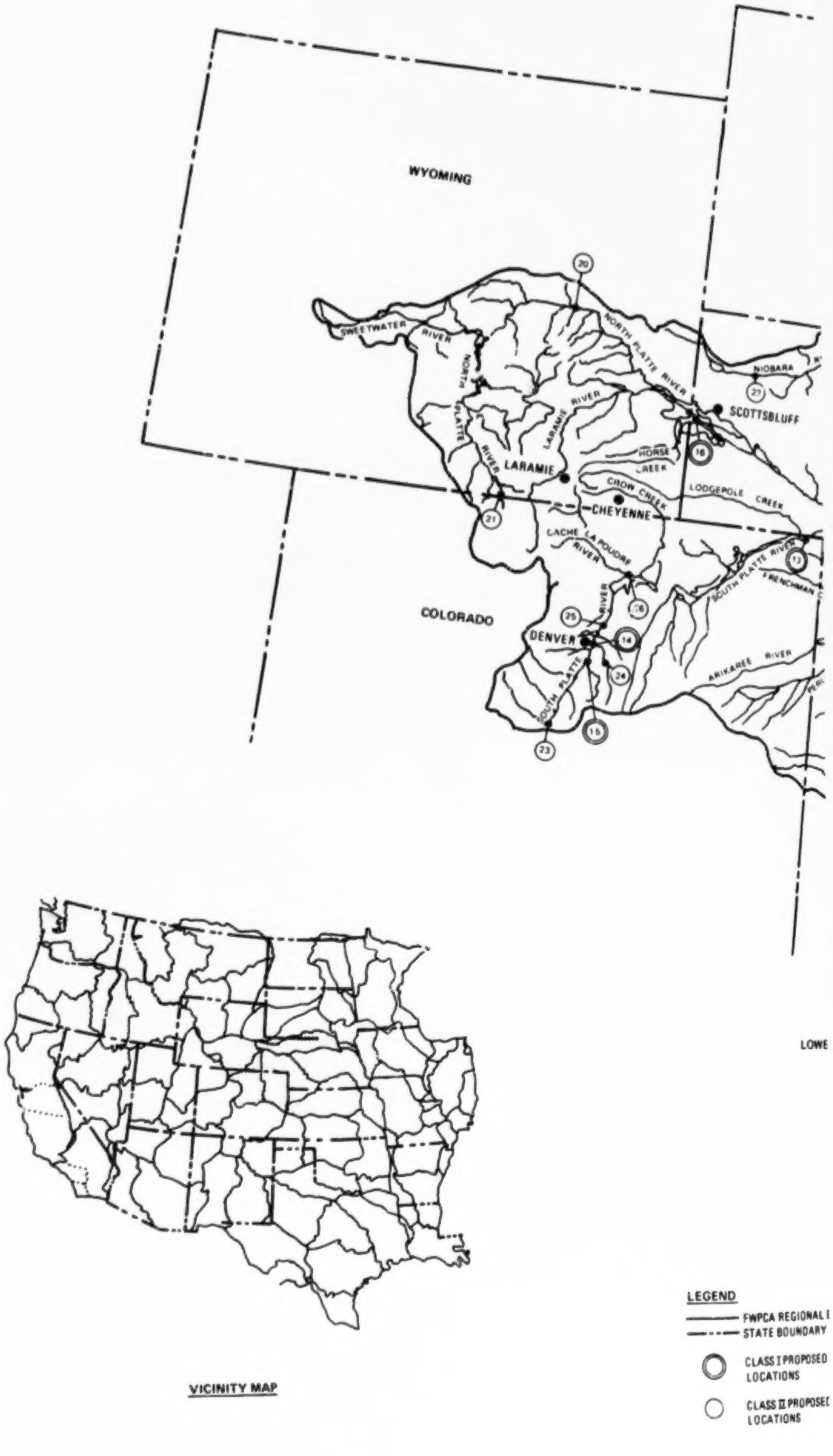

TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
FLORIDA
ROME
ATLANTA
BIRMINGHAM
DEMOPOLIS
COLUMBUS
TALLAHASSEE
PANAMA CITY
SIPSEY RIVER
BLACK WARRIOR RIVER
CAHABA RIVER
COOSA RIVER
TALLAPOOSA
ALABAMA RIVER
MOBILE RIVER
MOBILE BAY
CONECUN RIVER
PEA RIVER
CHOCTAWATCHEE RIVER
CHATTAHOOCHEE RIVER
APALACHICOLA RIVER
SPRING CREEK
FLINT RIVER
OCHLOCKONEE RIVER
PERDIDO RIVER
ESCAMBIA RIVER
BLACKWATER RIVER
YELLOW RIVER
EAST BAY
ESCAMBIA BAY
PENSACOLA BAY
CHOCTAWHATCHEE BAY
APALACHICOLA BAY
APALCHEE BAY
1
2
3
4
5
7
8
9
10
11
12
13
14
16
18
20
26
28
29
30
32
33
36
37
38
40
43
44
45
52
53
54
55
57
58
59
60
61
62
63
64
65

FIGURE 13
SOUTHEASTERN RIVER BASINS

B


WYOMING
COLORADO
SWEETWATER RIVER
NORTH PLATTE RIVER
LARAMIE RIVER
HORSE CREEK
CROW CREEK
LODGEPOLE CREEK
CACHE LA POUDRE RIVER
SOUTH PLATTE RIVER
FRENCHMAN C
ARIKAREE RIVER
NIOBARA
LARAMIE
CHEYENNE
SCOTTSBLUFF
DENVER
LOWE
13
14
15
16
20
21
23
24
25
26
27
LEGEND
FWPCA REGIONAL
STATE BOUNDARY
CLASS I PROPOSED LOCATIONS
CLASS II PROPOSE LOCATIONS

VICINITY MAP

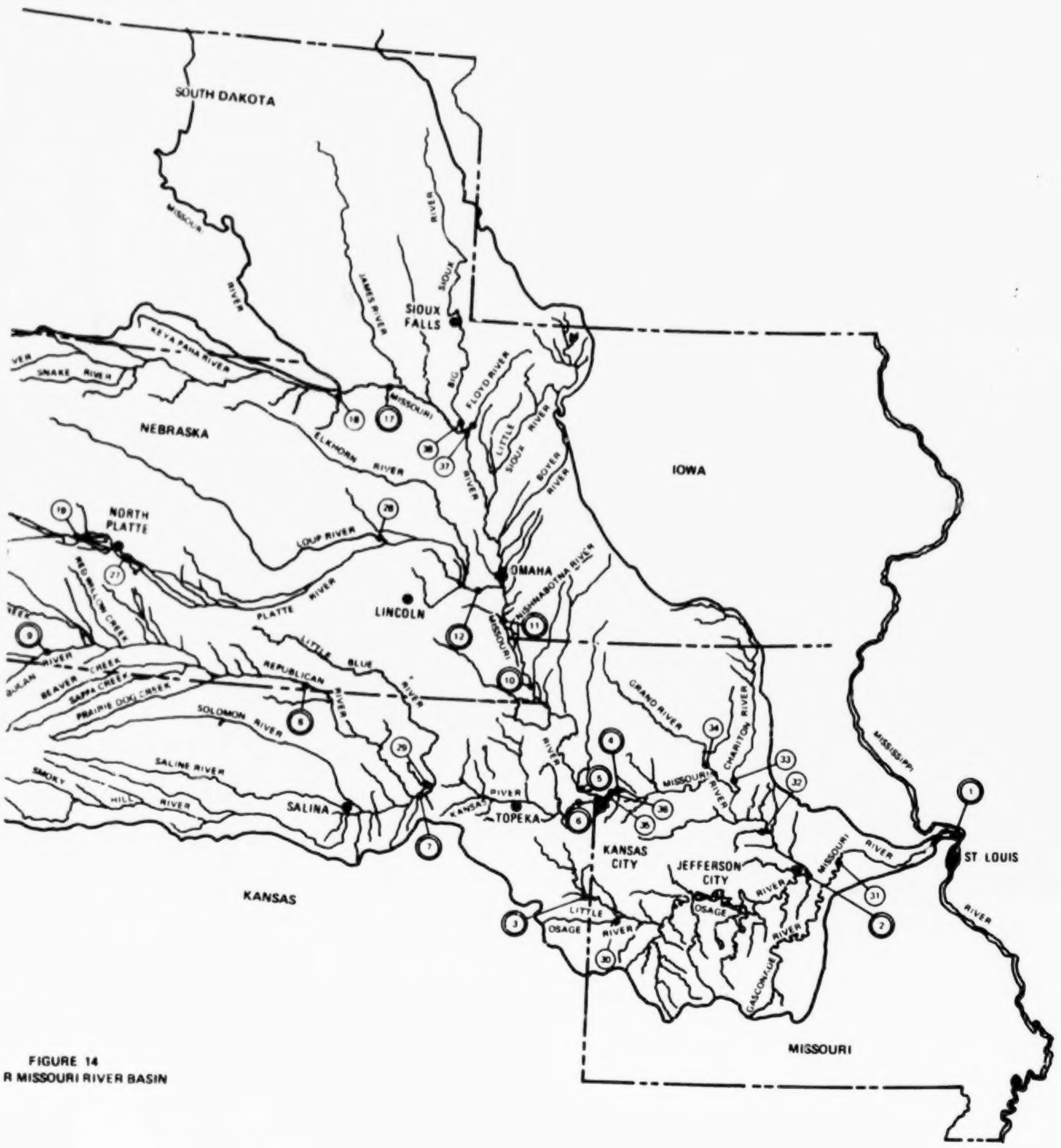

SOUTH DAKOTA
NEBRASKA
IOWA
KANSAS
MISSOURI
SIOUX FALLS
NORTH PLATTE
OMAHA
LINCOLN
SALINA
TOPEKA
KANSAS CITY
JEFFERSON CITY
ST LOUIS
MISSOURI RIVER
JAMES RIVER
SIOUX RIVER
BIG SIOUX
FLOYD RIVER
LITTLE SIOUX RIVER
BOYER RIVER
KEYA PAHA RIVER
SNAKE RIVER
ELKHORN RIVER
LOUP RIVER
PLATTE RIVER
NISHNABOTNA RIVER
LITTLE BLUE RIVER
REPUBLICAN RIVER
BEAVER CREEK
SAPPA CREEK
PRAIRIE DOG CREEK
SOLOMON RIVER
SALINE RIVER
SMOKY HILL RIVER
KANSAS RIVER
GRAND RIVER
CHARITON RIVER
LITTLE OSAGE RIVER
OSAGE RIVER
GASCONADE RIVER
MISSISSIPPI RIVER
1
2
3
4
5
6
7
8
9
10
11
12
17
18
19
27
28
29
30
31
32
33
34
35
36
37
38

FIGURE 14
R MISSOURI RIVER BASIN

:OUNDARY

MONITOR

MONITOR

SCALE
0 25 50 75 100
(In Miles)

1 Accession Number

2 Subject Field & Group
06A 07A 07C
06B 07B

SELECTED WATER RESOURCES ABSTRACTS
INPUT TRANSACTION FORM

5 Organization
Federal Water Pollution Control Administration

6 Title
DESIGN OF WATER QUALITY SURVEILLANCE SYSTEMS - PHASE I -
Systems Analysis Framework

10 Author(s)
Morgan, Paul V.
Johnson, Brownie R.
Bramer, Henry C.
Duncan, Wallace L.

11 Date
February, 1970

12 Pages
303

15 Contract Number
14-12-476

16 Project Number
16090DBJ

21 Note

22 Citation
Report No. 16090 DBJ 02/70 Water Pollution Control Research Series, F.W.P.C.A.

23 Descriptors (Starred First)
*Systems Analysis, *Water Quality, *Monitoring, *Legal Aspects, *Water Pollution, *Water Measurement, Water Quality Act, Water Quality Control, Water Quality Standards, Water Quality Criteria, Information Retrieval, Surveillance

25 Identifiers (Starred First)
*Ohio River Basin, *Tennessee River Basin, Missouri River Basin, *Southeastern River Basins, *Systems Analysis Framework, Water Quality Monitors

27 Abstract
In order to accomplish the goals of the Water Quality Act of 1965, it is necessary to establish water quality surveillance systems throughout the nation. It is highly imperative that the individual systems developed by the various Federal, state, and interstate agencies be compatible and their data systems be interconnected. The various inputs and decisions necessary to accomplish this task are so complex that modern systems analysis techniques should be applied to insure that each of these water quality surveillance systems are developed and designed utilizing the same criteria. This study is the initial effort to apply systems analysis techniques to the solution of this problem. Three major river basins were selected for this study in order to identify the parameters common to any basin throughout the nation. The three basins were studied by: (1) reviewing the literature associated with their water quality characteristics; (2) on-site visits to the river basin areas; (3) comparative review of the interstate water quality standards and plans of implementation; and (4) legal considerations in surveillance program design. These tasks provided the input material to develop a systems analysis framework. The systems analysis framework was applied manually to select sites for water quality surveillance stations on the major streams studied within the three river basins. This report was submitted in fulfillment of Program No. 16090DBJ and Contract No. 14-12-476 between the Federal Water Pollution Control Administration and the Cyrus Wm. Rice Division, NUS CORPORATION.

Abstractor
Paul V. Morgan

Institution
C. W. Rice Div.-NUS CORPORATION

WR:102 (REV. OCT. 1968)
WRSIC

SEND TO: WATER RESOURCES SCIENTIFIC INFORMATION CENTER
U.S. DEPARTMENT OF THE INTERIOR
WASHINGTON, D.C. 20240

☆ GPO: 1969-324-44

☆ U. S. GOVERNMENT PRINTING OFFICE : 1970 O - 403-762